United States Patent [19]

Petersen

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[54] **LONG NOSE LOCKING PLIER**

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[73] Assignee: Petersen Manufacturing Co., Inc., DeWitt, Nebr.

[21] Appl. No.: 241,085

[22] Filed: Mar. 6, 1981

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[52] U.S. Cl. 81/367; 81/418

[58] Field of Search ..... 81/367-380, 81/418, 425 R, 425 A, 427; 7/132, 133, 134, 125; D8/22, 52

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Primary Examiner—James L. Jones, Jr.

Attorney, Agent, or Firm—Lackenbach, Siegel, Marzullo, Presta & Aronson

[57] **ABSTRACT**

A long nose locking hand tool having a pair of opposing jaw members, a fixed handle and a movable handle and lever locking means therebetween for maintaining a toggle relationship between the jaws when in a closed position; and wherein each of said jaw members comprising a jaw face configuration having a total jaw length to average jaw height ratio of from about 6.5 to about 8.5 with a through jaw hardness range of from about 53 to about 57 Rockwell C, with said jaw members made of an alloy spring steel, said jaw members having a nominal parallel opening when they are spaced apart, approximately 3/16 inch, thereby enabling said jaw members to clamp a workpiece up to 3/16 inch thick with parallel jaw faces by flexing to the parallel condition when closed and returning to their original unstressed state when released of clamping pressure.

12 Claims, 4 Drawing Figures

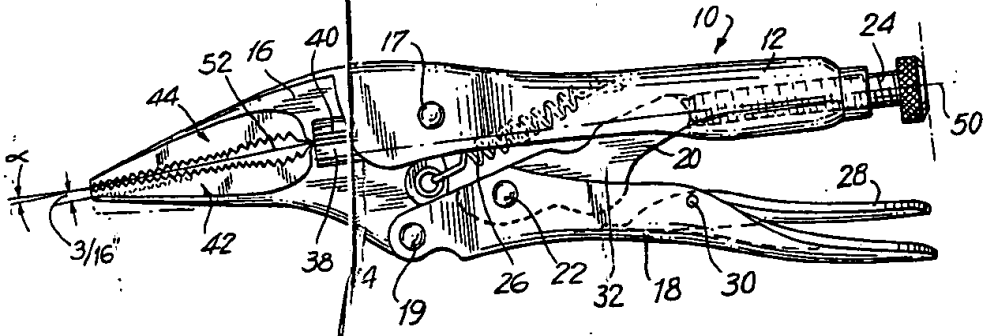

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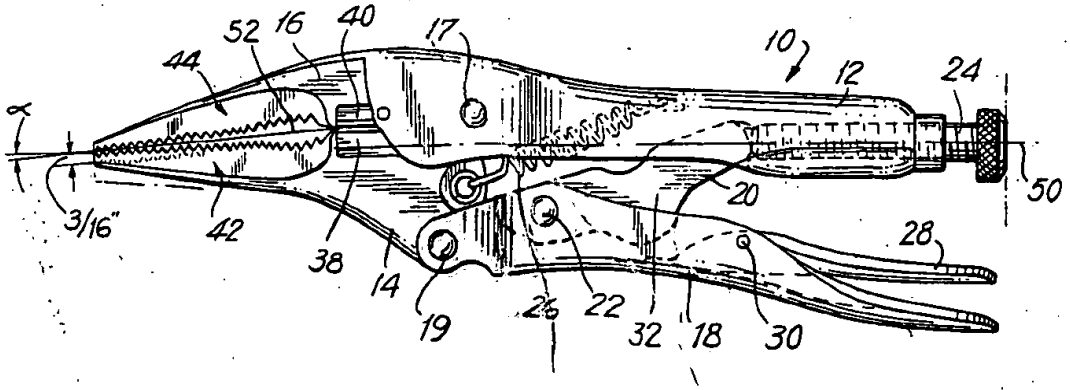
FIG. 1



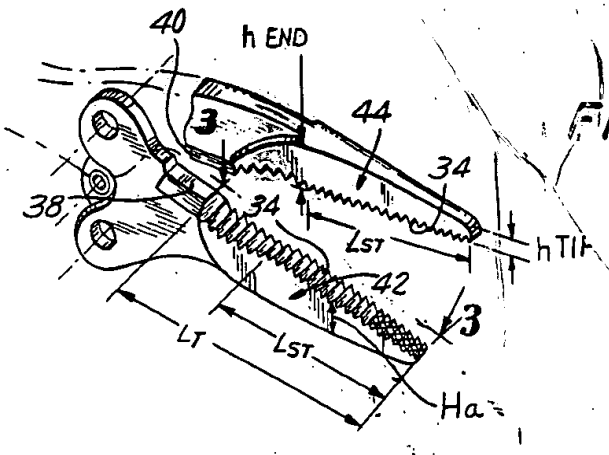
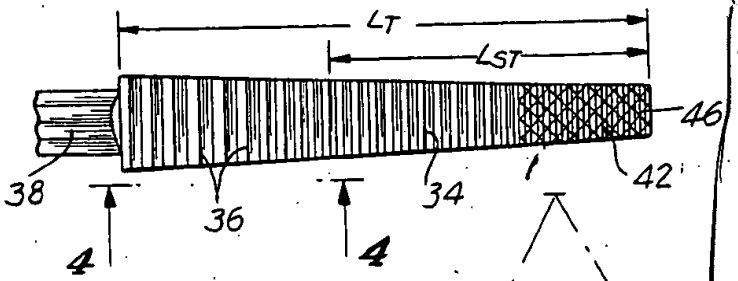


FIG. 2

FIG. 3



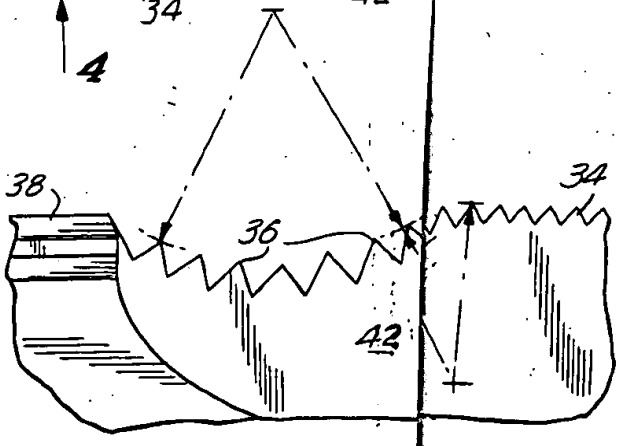


FIG. 4

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LONG NOSE LOCKING PLIER

This application is related to my earlier filed copending U.S. design patent application, Ser. No. 943,180, filed Sept. 18, 1978 now U.S. Pat No. Des. 261,096.

This invention relates to in general a class of locking hand tools, such as locking pliers, and more particularly to long nose locking pliers of the adjustable type embodying a locking toggle.

BACKGROUND OF THE INVENTION

Heretofore in the art, practically all locking pliers/-wrenches have been of the type generally comprising substantially large size or "big mouth" jaws for general duty use even though the nominal overall length of the tool may be different, say from small to large size, for example, five to ten inches. Furthermore, other more specific types of hand clamping tools embody modified jaw forms, such as C-shaped jaw members, straight jaws, curved jaws, pinch-off jaws, elongated flat plate-like jaws for sheet metal work, welding clamp jaws, or movable jaw members coupled with a chain clamping means enabling a work piece, such as a pipe, to be effectively gripped.

The following United States patents are representative of the class of locking tools in the art employing various jaw members and which also generally comprise handle members including some form of toggle-actuation for locking a workpiece between a pair of jaws of a locking plier or locking wrench.

Number	Date	Name
1,489,458	April 8, 1924	W. Petersen
2,201,918	May 21, 1940	W. Petersen
2,229,454	Oct. 20, 1942	H. C. Borchers
2,280,005	April 14, 1942	W. Petersen
2,341,489	Feb. 8, 1944	J. E., R. M. Tornberg
2,417,013	March 4, 1947	W. Petersen
2,563,267	Aug. 7, 1951	C. Petersen
2,590,031	Mar. 18, 1952	C. Petersen
2,641,149	June 9, 1953	C. Petersen
2,711,663	June 28, 1955	W. Petersen
3,192,804	July 6, 1965	C. Petersen, et al
3,585,704	June 22, 1971	J. A. Schroeder
3,590,669	July 6, 1971	Vincent Marasco

The above-identified Petersen patents are all precursers and forerunners of contemporary locking hand tools marketed for years by Petersen Manufacturing Co., Inc. of DeWitt, Nebraska 68341. A 1981 General Catalog is attached to this specification for the purposes of more particularly illustrating and providing additional descriptive material clearly disclosing the various models of Petersen's locking pliers and other locking hand tools, which incidentally and to this day are all identified by one or more "Vise-Grip" trademarks of Petersen Manufacturing Co., Inc.

In addition to the above-mentioned prior art patents, the following United States patents are examples of a class of more conventional pliers.

Number	Date	Name
1,141,786	June 1, 1915	W. O. Eilert
1,442,083	Jan. 16, 1923	A. J. Meyer
1,504,401	Aug. 12, 1924	W. C. Tull, et al
2,847,889	Aug. 19, 1958	F. O. Cain

Illustrative of recent pliers of the conventional class which have found wide use in numerous newer industries, such as those involving electronic and computer applications are the long nose, needle nose, curved needle nose and other specialty pliers as shown and described on pages 105 and 110 of a Proto Tool Catalog and page 12 of a Mathias Klein Tool Catalog, copies of which are available at the Patent and Trademark Office, but which are nevertheless also attached to this specification for the attention of the Patent and Trademark Office in order to facilitate its work in searching for prior art relevant to the present invention.

The only known prior art long nose locking plier is U.S. Pat. No. 3,600,986, granted to Earl M. Baldwin, Jr. on Aug. 24, 1971 (copy also enclosed with this application). This locking hand tool is also known by the trademark "Lever Wrench", a registered trademark of Leverage Tools, Inc. of Glenvil, Nebraska, 68941. This prior art Leverage company tool (Model #L-8) is a self-adjusting long nose toggle plier which is difficult to operate and even more difficult to adjust to a desired pressure. Moreover, the Lever Wrench is clumsy and awkward to use as a locking plier because upon pushing its movable lever handle outward to unlock the tool, the jaws do not at once begin to move apart, it being necessary to continue moving the lever handle outward through a considerable arc before the jaws actually begin to move apart, with the result that there is a great amount of lost motion and one's hand must be open much too far to move the jaws apart. Another disadvantage of the Lever Wrench tool is that it is case hardened, that is, the core is soft and only a thin outer skin or shell is hardened. Typical hardness readings of the jaw surfaces of such a long nose locking plier are about 58–60 Rockwell C scale with the skin or shell measuring about 0.005 inch at maximum. The core readings range from about 28–30 Rockwell C scale. Although the outer skin or shell exhibits suitable hardness for a long nose locking plier, the use of inherently lower grade steels causes the jaws, when under considerable pressure, in tightly gripping a workpiece, to easily deflect outwardly and bend excessively and to set permanently without spring back, thereby precluding restoration of the jaws to their original unstressed shape and condition even if such action is within elastic limits of the steels employed.

In addition to the above known long nose locking plier, applicant has filed in many foreign countries for equivalent design protection based on my U.S. Ser. No. 943,180 and a number of the counterpart Industrial Design applications have since been issued and registered as more particularly identified in my declaration accompanying this utility patent application.

One of the main disadvantages of the above-noted locking tools is that they are generally designed for various applications, and their configurations and structural elements, particularly the special shaped jaws are too blunt, short, or stubby to reach small or tight places and are generally not suitable or useful in tight quarters and for many delicate jobs. With my unique and novel long nose locking plier, any desired amount of pressure can be applied to hold small and fragile objects, such as jewelry, electronic components, tiny springs, cotter pins, etc., all with a fine fingertip like control.

SUMMARY OF THE INVENTION

It is, therefore, a principle object of the invention to provide an improved long nose locking plier which

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overcomes all of the disadvantages of the prior art locking tools.

Another object of the invention is to provide a long nose locking plier with a pair of jaws which are somewhat flexible and capable of springing back when released from a stressed pressure condition so long as the elastic limit of the metal tool is not exceeded.

A further object of the invention is to provide a long nose locking plier of a suitably hardened steel, and one which is entirely hardened through and through.

Yet another object of the invention is to provide a long nose locking plier which may be used for holding and starting nails in tight quarters where little room is available for the use of more conventional tools.

Still another object of the invention is to provide a long nose locking plier, which exhibits an improved dimensional ratio and a suitable hardness range, which together with the characteristics of the steel employed, imparts the desired flexibility to the jaws of the long nose locking plier.

Still further it is an object of the invention to provide a long nose locking plier constructed of an oil-hardened spring and tool steel having relatively high amounts of silicon and manganese.

Another object of the invention is to provide a long nose locking plier having a flexibility ratio expressed as a function of total jaw length to average jaw height.

Yet still another object of the invention is to provide a long nose locking plier having a flexibility ratio which is expressed as a function of the total length of the straight teeth portion of the jaw to the average jaw height.

These and other objects of the invention are achieved by a long nose locking plier having a pair of opposing jaw members, a fixed handle and a movable handle and lever locking means therebetween for maintaining a toggle relationship between the jaws when in a closed position; and wherein each of said jaw members comprising a jaw face configuration having a total jaw length to average jaw height ratio of from about 6.5 to about 8.5 with a jaw hardness range of from 53 to about 57 Rockwell C, with said jaw members made of an alloy spring and tool steel having about a 3/16 inch parallel opening enabling said jaw members to clamp a workpiece up to 3/16 inch thick with substantially parallel jaw faces.

The objects of the invention are also achieved by a long nose locking plier having a pair of opposing jaw members, a fixed handle having an adjustment screw, and a movable handle and lever locking means therebetween for maintaining a toggle relationship between the jaw faces of said jaw members when in a closed position; and wherein said fixed handle having a straight strike surface, and having an axis passing through said strike surface defining the direction of a line of force impartable to the hand tool, and the pair of jaws further defining a bi-secting axis or line formed by the angle of the jaws when closed against a workpiece gripped therebetween; and the angle between said axes being less than about 5° when the gripping tips of the jaw members are in a generally touching or closed position.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described and explained in greater detail, and the invention will be better understood and the objects will become apparent, when consideration is given to the following detailed description when taken with reference to the accompanying drawings which form an integral part of this patent application and wherein:

FIG. 1 is a side elevational view of my novel long nose locking plier with hidden parts shown in phantom;

FIG. 2 is a perspective view of the jaws of my locking plier, but with the upper jaw broken away to illustrate the entire lower jaw;

FIG. 3 is a plan view along the line 3—3 of FIG. 2; and

FIG. 4 is a greatly enlarged, fragmentary, side elevational view of the involute section of my teeth illustrating the reverse arcurate curve.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As best shown in FIG. 1, the long nose locking plier is generally designated by the reference numeral 10, and includes a handle member 12, and a movable clamping member or lower jaw 14. The handle member 12 is provided with a stationary clamping element or upper jaw 16. A toggle mechanism comprises an elongated handle member 18 and a toggle-link member 20 which is conventionally pivotally engaged at one end about the pin 22. The other free end (shown in phantom) of the toggle link member 20 is engaged with the handle member 12, and in particular the abutment end (also shown in phantom) of an adjustment screw 24 which is suitably threadably engaged at the end of the handle member 12. The forward end of the handle member 18 is preferably bifurcated or forked, and a corner portion of the movable clamping member 14 is suitably disposed within the fork or between the bifurcation arms by pivot pin means 19. Similarly, the handle member 12 is preferably channel-shaped, and receives another corner portion of the movable clamping element 14 which is also suitably secured thereto by means of a pivot pin 17.

Spring means 26, preferably in the form of an extension coil spring, is secured between the handle member 12 and the movable clamping element 14 or lower jaw, to urge the clamping element 14 away from the stationary clamping element when the jaws are opened.

An elongated release lever 28 is suitably pivotably mounted by means of a pin 30, to the inside of the handle member 18, and is provided with a forwardly extending portion(as shown in phantom) and is engageable with a projection 32 of the toggle-like member 20 which extends toward the handle member 18. When the release lever 28 is pivoted about the pin 30, the handle member 12 is moved away from the handle member 18.

It will be appreciated that the wrench or locking plier mechanism and toggle construction described herein with the exception of the long nose jaws conforms basically in accordance with the construction described in U.S. Pat. No. 1,489,458. Furthermore, such construction, the operation thereof, and the specific operation of the release lever is clearly set forth in U.S. Pat. No. 3,192,804. As explained in these Petersen prior art patents, closing of a locking wrench or plier incorporating a toggle device is effected by moving the relatively movable handle member 18 toward the relatively fixed handle member 12. This movement forces the upper end of the toggle-like member 20 to move inwardly towards the handle member 12. The pivot pin 22 also moves inwardly, and when such pivot pin moves over center, the plier is locked in a closed position.

With reference to FIGS. 2-4, each jaw member 14, 16 comprises a straight front portion 34 with transverse teeth and a reverse involute curved portion 36 with

similar transverse teeth at the rearward portion of the jaws. A conventional wire cutter comprising a lower blade **38** is positioned at the inner portion of the working face of the movable jaw member **14** and an upper anvil **40** is positioned at the inner portion of the working face of the fixed jaw member **16**. The blade **38** is suitably oppositely beveled as is conventional in the art. At the extreme front end or tip portions of the jaws **14** and **16**, suitable gripping means in the form of a knurl **46**, are provided for about a length of ⅜ inch in lieu of transverse teeth. The involute curvatures of the jaws enable large round bodies as well as polygonal shaped bodies, such as hex nuts, bolt heads and the like to be grasped in such a manner that opposite flat surfaces thereof will be engaged over substantially the entire area of such surfaces and accordingly there is a firmer grip upon the nut or bolt head. FIG. **4** clearly illustrates the reverse curvature of the involute sections which follows the radial paths shown by the radii drawn in dot-dash lines.

For a more complete understanding of the curved jaws, reference is made to my U.S. Pat. No. 2,563,267 noted hereinabove with reference to the prior art background of the invention.

As best shown in FIGS. **2** and **3**, the jaw faces or portions **42, 44** are wider than the main body of the jaw members **14, 16** and generally taper a few degrees from the widest point at the end of the involute portion **36** to the narrowest point representing a thin jaw tip **46** at the ends of each jaw face or portion **42, 44** of my long nose locking plier. Preferably, the width or jaw thickness at the tips is about ⅛ inch and at the base thereof is about 5/16 inch. It should also be noted that the jaw members are shown in phantom in FIG. **1** to be spaced in a parallel position at a nominal distance of about 3/16 inch. These jaw faces or portions **42, 44**, which preferably are straight for a length of about 1¼ inches (overall length being about 1¾ inches), when pivoted away from each other are in parallel at said predetermined set position of separation which in the present invention occurs at the nominal spacing of about 3/16 inch which is preferred as below the 3/16 inch spacing most use and applications of the long nose locking pliers would take place, whether one is handling or installing small parts, pulling or bending pins, wires, keys, etc., retrieving fish hooks, clamping parts, or cutting a piece of hard spring wire or a minute mono-filament winding material. Also, most small items or parts can be gripped with a substantial portion thereof lying flat on the jaws, in contrast to being just gripped at the tip of the jaws, as for example when using conventional long nose pliers, which jaws are all essentially parallel at zero, and have a plain simple scissors action when a part is squeezed between the jaws. The jaw adjustment, nevertheless, is capable of opening to about 2¼ inches at the tips, and 1 inch at the base thereof at maximum condition. However, with a workpiece larger than 3/16 inch, the jaw faces are incapable of attaining a paralleled position when the workpiece is gripped therebetween.

With the jaws of the present invention, a parallel opening is maintained as a part is gripped and squeezed therebetween so long as the size of the workpiece is within nominal 3/16 inch parallel size opening. Thus, even with a very tiny part of 1/16 inch or less, once the jaws are locked down on it, the narrow ends of the jaws flex or spring to assume the part's thickness and thereby positively and tightly hold the part with a parallel jaw condition. The long nose jaw members are formed so as to provide elasticity to them enabling a parallel condition to be created when the jaws are locked and squeezed about a workpiece. The built-in jaw resiliency enables the jaw members to spring to the size of the clamped workpiece. Thus, the actual parallel opening between the jaws when being used, is the effective thickness of the part. Of course, and as noted hereinabove, the effective parallel opening of the jaw members from the nominal 3/16 inch parallel opening is only experienced in the downward or smaller dimension as no such parallelism between the jaws can be achieved if a workpiece larger than the nominal 3/16 inch parallel opening is clamped.

The long nose jaw members are, therefore, critical in their construction and their profile is important in that each of the jaw members preferably have a jaw face configuration having a total jaw length (Lt) to average jaw height (Ha), ratio of from about 6.5 to about 8.5 with a jaw hardness range of from about 53 to about 57 Rockwell C scale, with the jaw members made from an alloy steel having properties of desired strength and toughness, as well as requisite flexibility. The average jaw height (Ha) being the average of the minimum jaw height at the tip thereof and the jaw height at the last or end straight tooth adjacent the curved portion **36**. FIG. **2** best illustrates these relative dimensions, along with dimensions which establish a more preferred jaw face configuration where the straight flat jaw portion length (Lst) to average jaw height (Ha) ratio is from about 4.5 to about 6.5.

An even more preferred range of the straight flat jaw portion length (Lst) to average jaw height (Ha) ratio is from about 5 to about 6, with a most preferred ratio of about 5.5.

A more preferred range of the total jaw length (Lt) to average jaw height (Ha) ratio is from about 7 to about 8, with a most preferred ratio of about 7.5.

A more preferred jaw hardness range, on the other hand, is from about 54 to about 55 Rockwell C scale, using an oil-hardening alloy spring and tool steel having relatively higher amounts of silicon and manganese than other plain carbon tools or alloy tool steels. Below Rockwell 53, the steel is too soft and above Rockwell 57, the steel may break.

As best shown in FIG. **1**, the fixed handle has a strike surface (straight flat surface of knurled end knob of the adjustment screw **24**) and has an axis **50** passing through the strike surface defining the direction of a line of force impartable to the locking plier.

This axis, identified by the reference numeral **50**, passes from the gripping tip or end edge of the fixed jaw face through about the center line of the adjustment screw **24** and it defines the line of force impartable to the tool, such as for example, if one were to strike the flat head of the adjustment screw **24** with a tack hammer. The axis passing through the straight strike surface forms an angle with said straight strike surface of from about 87° to about 93°, and said axis also passing through the gripping end tip or end edge of the fixed jaw face. Another axis line **52** defines a bisection line formed by the angle of the jaws when closed and gripped against a workpiece. The angle α between these two axes in the long nose locking plier of the present invention is less than about 5° when the gripping tips of the jaw members are in a generally touching or closed position. With such a small angle between the two axes, a nail such as a brad held by its head at the jaw tips and with the nail axis along the bisection line **52** can be easily started by simply tapping the head of the adjust-

ment screw 24. Here the line of force of the blow to the head, which is substantially parallel to the body of the locking plier, is such that the force transmitted is virtually in line with the axis of the nail, rather than at an angle thereto which is less effective in starting the nail as the blow would tend to cause the nail to be deflected or bend since the force or blow is not directed along the nail axis. Also, with the structural arrangement of my small nose locking plier, no torque or rotating couple about the nail can take place as the force is transmitted substantially in line with the axis of the nail which is to be started.

It will be appreciated that the resiliency of the jaw members decrease or diminish as the thickness of the jaws increase. Consequently, most of the elastic action and bending takes place at the front ends of the jaw members which are more slender. Thus, the flexibility of the jaw members is a function of the L/H ratio and the higher the ratio, the greater the flexibility for a given or constant width and same tool steel material. It is, therefore, critical that the tips of the jaw members are thin in cross-section as if they have too much thickness, no bending or flexing action can take place when a workpiece is clamped (within the nominal 3/16 inch parallel opening) between the jaws. On the other hand, embodying long slender needle-like jaws would result in failure as the tips thereof would be very weak, and would easily break with the slightest pressure applied to a locking plier.

The 3/16 inch parallel opening, although not critical, is also important in that greater dimensions, such as ¼ inch, ⅜ inch or ½ inch, a person would not be strong enough to spring the jaws sufficiently to assume a parallelism relationship about a workpiece, except on an object that is approximately the same size as the nominal parallel jaw opening. However, with a 3/16 inch nominal parallel opening, one easily has sufficient power to "parallel" grip a small part which is of a size 3/16 inch or less, and with such a sized long nose locking plier, most delicate job requirements calling for a long nose tool would generally fall into this lower range. Obviously, with larger items, one would not consider employing a long nose locking plier.

Although the present invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, it will, of course, be understood that various changes and modifications may be made in the form, details, and arrangements of the parts without departing from the scope of the invention as set forth in the following claims.

What is claimed is:

1. A long nose locking hand tool having a pair of opposing jaw members, a fixed handle and a movable handle and lever locking means therebetween for maintaining a toggle relationship between the jaws when in a closed position; and wherein each of said jaw members comprising a jaw face configuration having a total jaw length to average jaw height ratio of from about 6.5 to about 8.5 with a through jaw hardness range of from about 53 to about 57 Rockwell C, with said jaw members made of an alloy spring steel, said jaw members having a nominal parallel opening when they are spaced apart approximately 3/16 inch, thereby enabling said jaw members to clamp a workpiece up to 3/16 inch thick with parallel jaw faces by flexing to the parallel condition when closed and returning to their original unstressed state when released of clamping pressure.

2. The long nose locking hand tool according to claim 1, wherein each said jaw face includes a straight flat jaw portion and a curved jaw portion and the straight flat jaw portion length to average jaw height ratio is from about 4.5 to about 6.5.

3. The long nose locking hand tool according to claim 2, wherein the straight flat jaw portion length to average jaw height ratio is from about 5 to about 6.

4. The long nose locking hand tool according to claim 3, wherein the straight flat jaw portion length to average jaw height ratio is about 5.5.

5. The long nose locking hand tool according to claim 1, wherein the total jaw length to average jaw height ratio is about 7 to about 8.

6. The long nose locking hand tool according to claim 5, wherein the total jaw length to average jaw height ratio is about 7.5.

7. The long nose locking hand tool according to claim 1, wherein the jaw hardness range is from about 54 to about 55 Rockwell C.

8. The long nose locking hand tool according to claim 1, wherein said alloy spring steel imparts flexibility to said jaw members, which flexibility is expressed as a ratio or function of length of the teeth portion of said jaw to the average jaw height such that as a workpiece within the nominal parallel sized opening is gripped between said jaws, the jaw faces spring to the size of the clamped workpiece and attain a generally stressed parallel condition and subsequently spring back to their nominal parallel opening when the workpiece is released.

9. The long nose locking hand tool according to claim 1, wherein the jaw faces of said jaw members taper a few degrees from their widest point or thickest portion at the end of the jaw faces to the narrowest point of thinnest portion at the tip of the jaws.

10. The long nose locking hand tool according to claim 8, wherein the flexing and elastic action takes place mostly at the front ends of the jaw members.

11. The long nose locking hand tool according to claim 10, wherein as the thickness of said jaws increase, the resiliency and flexibility of the jaws decrease.

12. The long nose locking hand tool according to claim 11, wherein the higher the L/H ration, the greater the flexibility of said jaw members for a given width and same tool steel material.

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United States Patent [19]

Sauer et al.

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[54] **SURGICAL DEVICE TO PREPARE BODY TISSUE FOR ANASTOMOSIS**

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[73] Assignee: **Lasersurge, Inc.**, Rochester, N.Y.

[21] Appl. No.: **296,873**

[22] Filed: **Aug. 26, 1994**

Related U.S. Application Data

[63] Continuation of Ser. No. 957,601, Oct. 6, 1992, abandoned.

[51] **Int. Cl.**[6] **A61B 17/125**; A61B 17/32

[52] **U.S. Cl.** **606/167**; 606/171; 606/207

[58] **Field of Search** 606/167, 181–183, 606/135, 174, 175, 151, 157, 158; 128/843

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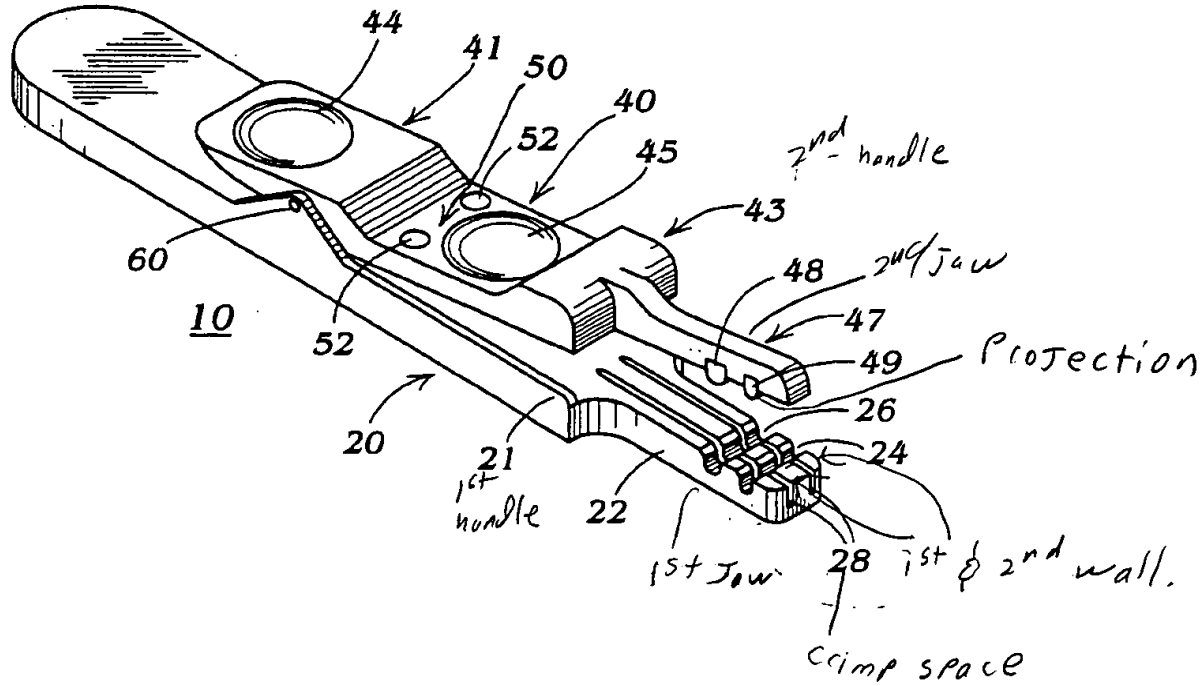
Primary Examiner—Tamara L. Graysay

[57] **ABSTRACT**

The present invention provides a surgical device which atraumatically compresses body tissue and guides a cutting blade to transect the body tissue. Included in the surgical device is a base member equipped to hold body tissue and accurately guide a cutting blade to sever tissue at a predetermined location. A pressure applying member, preferably an arm pivotally connected to the base member, atraumatically compresses a portion of the body tissue through a compliant finger projecting from its distal end. The complaint finger is configured and dimensioned to engage the holding portion of the base member, preferably a groove formed within the base member. Parallel guiding members intersect the holding portion of the base member to guide a cutting blade substantially perpendicular to the body tissue during tissue severance.

21 Claims, 5 Drawing Sheets



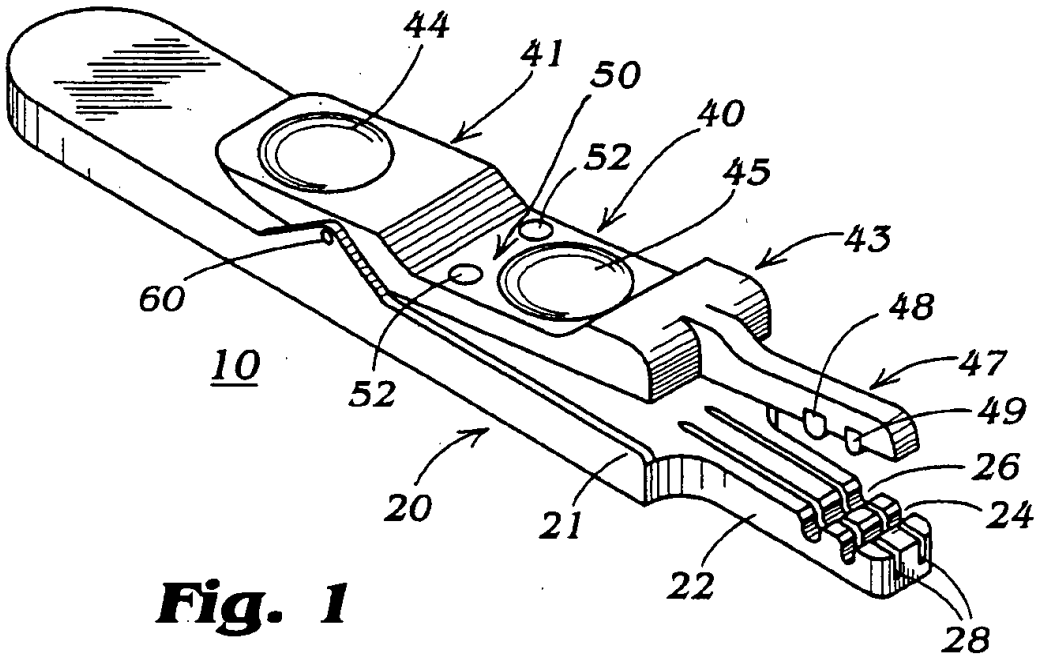


Fig. 1

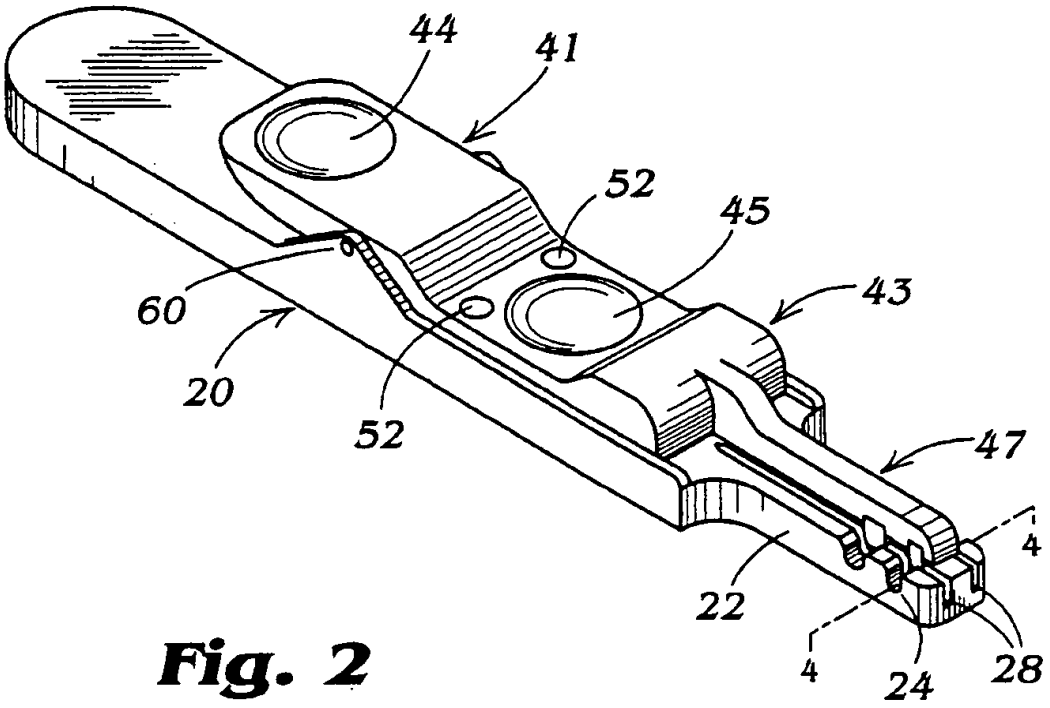


Fig. 2

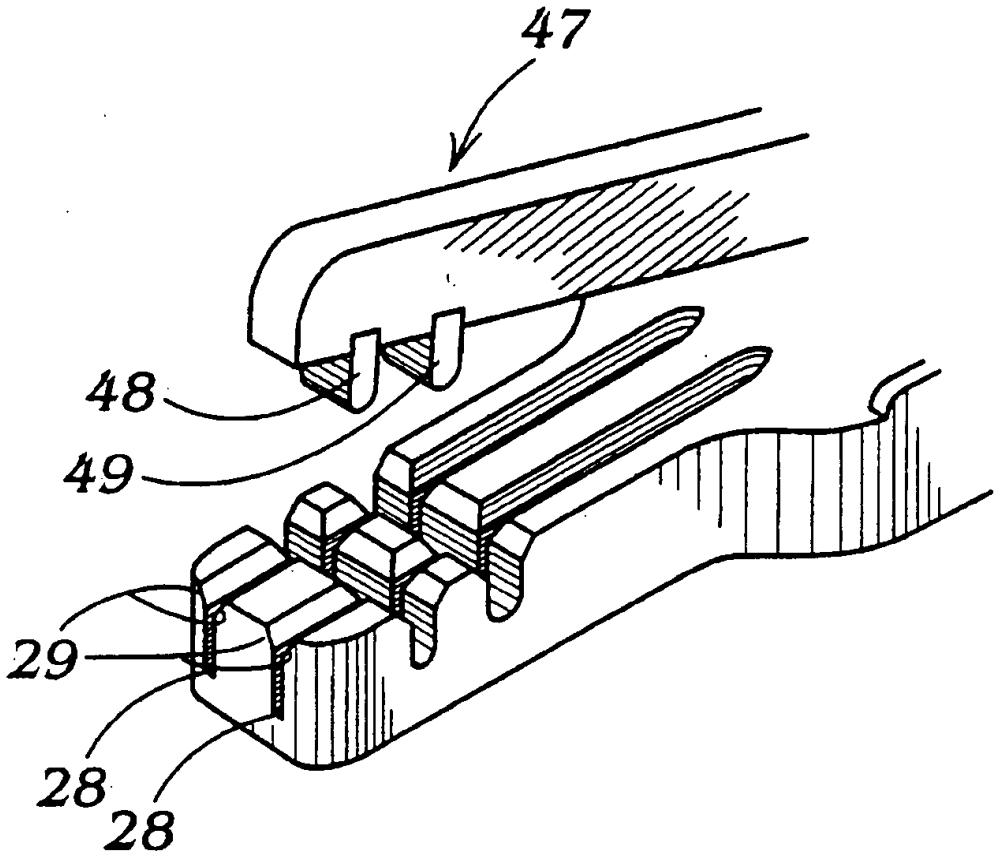


Fig. 3

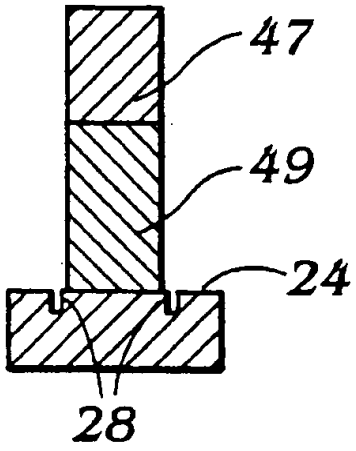


Fig. 4

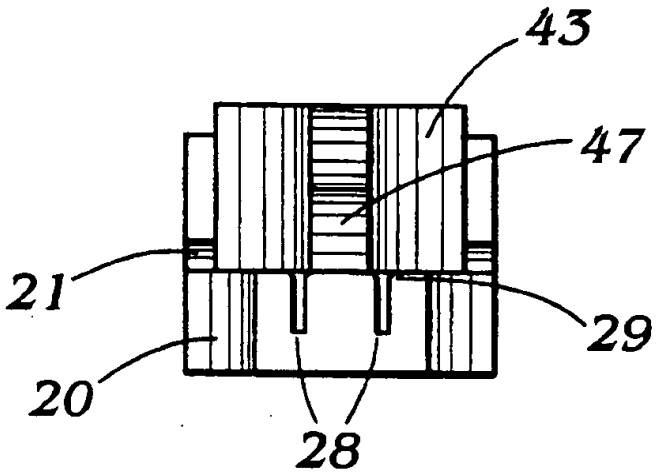


Fig. 5

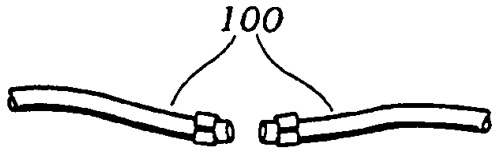


Fig. 6a

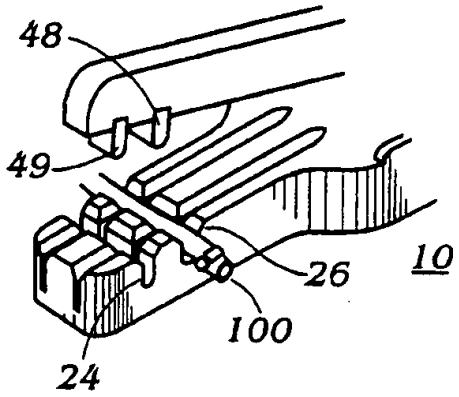


Fig. 6b

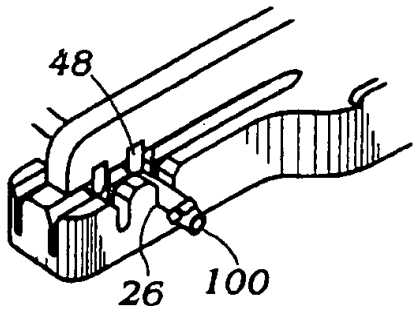


Fig. 6c

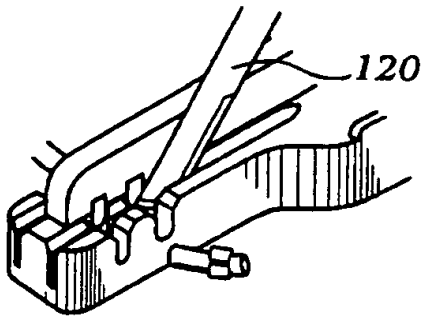


Fig. 6d

Fig. 6e

SURGICAL DEVICE TO PREPARE BODY TISSUE FOR ANASTOMOSIS

This is a continuation of application Ser. No. 07/957,601 filed on Oct. 5, 1992, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to surgical devices for holding tissue to be cut and, more particularly, to a device for providing compression to a portion of body tissue and for providing guidance for a cutting blade to cut the body tissue.

2. Brief Description of the Related Art

Anastomotic procedures are well known in the surgical arts. As used herein, anastomosis is any surgical procedure which unites parts or branches of vessels, organs, or other tissue structures, such as nerves and tendons, such that the vessels, organs or tissue structures communicate by collateral channels. Typically, tissue is cut on either side of a pathologic segment to facilitate removal of the segment. Successful reconnection of the remaining tissue portions depends upon the shape and condition of the severed ends remaining in the patient. To optimize tissue for most types of reconnections, the severed tissue ends remaining in the patient should be cleanly and consistently transected. The inner layers of the tissue should not bulge or protrude toward the anastomotic line relative to the outer layers, i.e., the layers of the severed tissue ends must be flush.

Prior art surgical cutting devices fail to provide severed tissue ends of the quality needed for subsequent anastomosis. Conventional instruments such as scalpels, razors, scissors, and the like, transect tissue without differential compression along the tissue section length during cutting. Without such differential compression, the severed tissue ends tend to display bulging of their inner contents, forming unsatisfactory hemispherical end profiles.

Current instruments for preparing tissue structures for subsequent anastomosis fail to cut the structures under the necessary differential compression for optimal tissue end profiles. For example, U.S. Pat. No. 4,872,455 to Pinchuk et al. describes a device for trimming a tubular structure to mate with a similarly trimmed end of a second tubular structure. The device comprises a pair of pivotally-connected arms, one of which carries a cutting element and the other of which carries a V-shaped notch. A tubular structure sits in the notch as the arms are approximated, cutting the tubular structure. No element of the Pinchuk device compresses the tubular tissue prior to or during the cutting stroke, thus no differential compression is provided.

A need in the art therefore exists for a surgical device which applies differential compression along the length of a tissue structure while providing guidance for a cutting blade to transect the structure. Such a device would permit the user to safely and easily prepare vessels, organs, and other tissue structures for subsequent anastomosis by providing severed tissue end profiles having flush inner and outer layers.

SUMMARY OF THE INVENTION

The present invention provides a surgical device for preparing body tissue for anastomosis. The device atraumatically compresses body tissue and guides a cutting blade to transect the body tissue. Included in the surgical device is a base member equipped to hold the body tissue and accurately guide a cutting blade to sever tissue at a predetermined location. A pressure applying member, preferably an arm pivotally connected to the base member, atraumatically compresses a portion of the body tissue through a compliant finger projecting from its distal end. The compliant finger is configured and dimensioned to engage the holding portion of the base member, preferably a groove formed within the base member.

To guide a cutting blade for tissue transection, guiding elements are formed in the base member. Preferably, the guiding elements take the form of parallel grooves which intersect the holding portion of the base member on either side of the region cooperating with the pressure-applying compliant finger. The grooves guide a cutting blade, e.g., a scalpel or razor blade, such that the blade is substantially perpendicular to the body tissue during tissue severance.

The present invention also provides a method for preparing body tissue for subsequent anastomosis using the novel surgical device. In this method, tissue is provided with two severed ends using the above-described surgical device, the portion between the severed ends being removed. The severed ends are subsequently anastomosed by conventional surgical procedures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the surgical instrument of the present invention in an open position.

FIG. **2** is a perspective view of the instrument of the present invention in a closed position.

FIG. **3** is an enlarged perspective view of the distal end of the instrument of FIG. 1.

FIG. **4** is a transverse cross-section across the tissue groove at line 4—4 of FIG. 2.

FIG. **5** is a distal end view of the instrument of FIG. 1.

FIG. **6A–6E** are views of the instrument of the present invention as used in a vasectomy reversal procedure:

FIG. **6A** shows a vas deferens to be cut using the instrument of the present invention;

FIG. **6B** shows the vas inserted into the instrument;

FIG. **6C** shows the instrument being closed to compress a portion of the vas;

FIG. **6D** shows a scalpel blade inserted into the instrument to transect the vas;

FIG. **6E** shows the vas deferens following transection and anastomosis.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings in detail where like reference numerals indicate like elements in each of the several views, reference is first made to FIGS. 1 and 2 wherein a surgical device for compressing body tissue and providing cutting blade guidance **10** is depicted. The device **10** includes a base member **20** adapted to hold body tissue and guide the cutting blade and compression arm **40** pivotally mounted thereto by means of pivot pin **60**. Ridge **21** provides alignment support between base member **20** and compression arm **40**.

Base member **20** has a flat, elongated configuration to facilitate gripping by the user. At its distal end, a working head **22** extends from the base member. This head serves as the template portion of the instrument, holding tissue to be cut in operative relation to the blade-guiding elements. Disposed in head **22** and transverse to the longitudinal axis

thereof are tissue-capturing grooves **24** and **26**. Grooves **24** and **26** traverse the width of working head **22** and, in a preferred embodiment, have a generally U-shaped cross-section with beveled upper edges, best seen in FIGS. **3** and **5**. The shape of grooves **24** and **26** may be configured for use with the particular type of body tissue to be cut. Preferably, grooves **24** and **26** are of unequal size, making the device capable of severing a range of body tissue structures.

Parallel to the longitudinal axis of head **22** and generally perpendicular to tissue-capturing grooves **24** and **26** are grooves **28** for guiding the cutting blade used to sever the body tissue. The guiding grooves intersect the tissue-capturing grooves and orient the cutting blade so that it remains perpendicular to the tissue. At their lowermost edges, grooves **28** penetrate more deeply into head **22** than do grooves **24** and **26** (FIG. **4**), assuring correct blade orientation at the point of tissue transection. In use, a standard scalpel or razor blade or the like is inserted into a groove and is drawn proximally toward and through the specimen to provide tissue transection. Upper groove edges **29** are beveled, FIGS. **3** and **5**, to facilitate blade insertion into the guiding grooves. To protect the user's hand from the cutting blade, compression arm **40** includes shoulder section **43** which acts as a blade stop between scalpel grooves **28** and the user's hand.

To gently compress the body tissue held in groove **24** or **26**, a pressure applying pivotal arm **40** is provided. As best seen in FIGS. **1** and **2**, the arm comprises a proximal gripping section **41**, shoulder section **43**, and compressing head section **47**. Arm **40** is pivotally mounted to base member **20** through pivot pin **60**. The arm is biased to a closed position, FIG. **2**, in contact with base member **20**, through tensioning mechanism **50**. Two urethane springs **52**, attached between the arm and the base member distal to pivot pin **60**, provide the appropriate arm compression on the tissue structure during transection.

Gripping section **41** includes opening finger grip **44** and closing finger grip **45**. Opening finger grip **44**, a generally circular-shaped depression in the proximal end of arm **40**, allows the user to conveniently open the arm to position tissue in the appropriate base member groove. Closing finger grip **45**, similarly shaped to grip **44** and located distally therefrom, permits application of additional holding power, if needed, during positioning of the body tissue. Note however, that tensioning mechanism **50** alone provides the appropriate compression on the tissue structure during transection. Because grip **45** is placed behind shoulder section **43**, the user's finger is shielded from the working head region.

Compressing head section **47** extends distally from shoulder section **43** and includes compliant fingers **48** and **49**. Fingers **48** and **49** have generally U-shaped cross sections adapted to engage grooves **26** and **24**, respectively, to gently compress the body tissue held therein. As with tissue-holding grooves **24** and **26**, fingers **48** and **49** can be configured for compressing a particular type of body tissue to be cut, thus a variety of shapes for the compliant fingers and tissue grooves are contemplated. Preferably, the compliant fingers are fabricated from a resilient, elastomeric material to atraumatically compress the tissue.

As best seen in FIGS. **2** and **4**, the width of head section **47** and fingers **48** and **49** is less than the width of base member working head **22** so as to provide differential compression along the length of the tissue captured in grooves **24** and **26**. The width is equal to the distance between guiding grooves **28**, the head being centrally disposed between and adjacent to the guiding grooves during arm closure. In this position, guiding grooves **28** intersect tissue-holding grooves **24** and **26** immediately adjacent the edge of arm **40** and fingers **48** and **49**. Thus, body tissue disposed in a tissue groove is compressed in the portion of the groove beneath the finger and is uncompressed in the remaining portions of the groove on either side of the finger. This configuration provides the differential compression during tissue severance necessary to provide a surface suitable for anastomosis. Tissue ends severed by the surgical instrument have a flush profile, i.e., inner and outer tissue layer surfaces are even with one another.

OPERATION

The surgical instrument of the present invention has particular application in severing the vas deferens during a vasectomy reversal procedure (vasovasotomy) as illustrated in FIGS. **6A–6E**. In this procedure, a routine technique for exposure of a vasectomy site **100** shown in FIG. **6A**, through both sides of the scrotum is performed. The surgical instrument **10**, held open by pressing grip **44**, is slid under the vas deferens on the testicular side of the vasectomy granuloma, FIG. **6B**. The vas is placed in the approximately-sized tissue holding groove, here, **26**. The instrument is closed, FIG. **6C** with the corresponding finger **48** gently compressing the vas held in the tissue groove. If further dissection or manipulation is necessary, the vas can be more securely held by applying pressure on closing finger grip **45**.

Prior to cutting, finger pressure is released from the closing finger grip allowing tensioning mechanism **50** alone to provide the necessary tissue compression. A standard scalpel blade **120** is placed in the distal end of the blade-guiding groove adjacent the specimen side of the compliant finger. The blade is drawn toward and through the specimen to provide tissue transection, FIG. **6D**. The instrument is then opened and removed.

To transect the contralateral side, the instrument is opened and placed on the abdominal (prostatic) side of the vasectomy granuloma. The vas is placed in the appropriately sized tissue groove and the instrument is closed. The same cutting technique is followed using the opposite blade-guiding groove, which should be placed adjacent to the specimen side of the tissue. The resultant tissue structures remaining in the patient, i.e., the portion cut under gentle compression, have flush anastomotic surfaces. The uncompressed sides having exaggerated bulging are discarded with the resected specimen.

Routine assessment of the vas patency and seminal sperm content are conducted. Further vas resection using the instrument can be performed if necessary.

The proximal and distal flush, cut edges of the vas are then anastomosed according to standard surgical procedures, FIG. **6E**.

While the invention has been particularly shown and described with reference to the preferred embodiments, it will be understood by those skilled in the art that various modifications and changes in form and detail may be made without departing from the scope and spirit of the invention. Accordingly, modifications such as those suggested above, but not limited thereto, are to be considered within the scope of the invention.

What is claimed is:

1. A surgical device for preparing body tissue for anastomosis by compressing body tissue and guiding a cutting blade comprising:

a base member having at least one holding groove for holding body tissue and at least one guide groove oriented substantially perpendicular to and intersecting said at least one holding groove for guiding a cutting blade;

a pressure-applying member cooperating with said base member, said pressure-applying member including a compliant finger located adjacent a distal end of said pressure applying member for atraumatically engaging and compressing a portion of said body tissue held within said at least one holding groove.

2. A surgical device according to claim **1** wherein said pressure-applying member comprises an arm mounting said compliant finger and pivotally mounted to said base member.

3. A surgical device according to claim **2** wherein said arm further comprises at least one finger grip for applying pressure to said arm.

4. A surgical device according to claim **2** further comprising means for urging said arm and said at least one compliant finger against said base member.

5. A surgical device according to claim **4** wherein said urging means comprises tension springs.

6. A surgical device according to claim **2** wherein the width of said arm and said compliant finger is less than the length of said at least one holding groove such that differential compression is applied along the length of body tissue.

7. A surgical device according to claim **2** wherein said at least one guide groove for guiding a cutting blade is positioned on said base member such that when said arm is seated against said base member said guiding groove is parallel and adjacent to said arm.

8. A surgical device according to claim **7** wherein said at least one guide groove for guiding a cutting blade comprises a pair of guide grooves positioned on said base member such that when said arm is seated against said base member said pair of guide grooves are parallel to and adjacent either side of said arm.

9. A surgical device according to claim **1** wherein said at least one holding groove for holding body tissue comprises two holding grooves of unequal size.

10. A surgical device for preparing body tissue for anastomosis by compressing body tissue and guiding a cutting blade comprising:

a base member having at least one holding means for holding body tissue and at least one groove for guiding a cutting blade substantially perpendicular to and intersecting said at least one holding means;

a pressure applying member cooperating with said base member, said pressure applying member including a compliant finger adapted to atraumatically compress a portion of said body tissue held within said at least one holding means, said compliant finger being provided with a curved tissue contacting surface dimensioned to fit within said at least one holding means for holding body tissue.

11. A surgical device for preparing body tissue for anastomosis by compressing body tissue and guiding a cutting blade comprising:

base means having means for holding body tissue and means for guiding a cutting blade, said guiding means disposed substantially perpendicular to and intersecting said means for holding body tissue and said means for holding body tissue includes at least one holding groove in said base means; and

pressure applying means including a compliant finger to compress a portion of body tissue held by said at least one holding groove.

12. A surgical device according to claim **11** wherein said means for guiding a cutting blade comprises at least one guiding groove in said base means.

13. A surgical device according to claim **11** wherein said compliant finger is pivotally mounted to said base means.

14. A surgical device according to claim **11** wherein said compliant finger is configured and dimensioned to fit against said at least one holding groove.

15. A surgical device according to claim **11** further comprising tensioning means to urge said pressure applying means against said base means.

16. A method for preparing body tissue for subsequent anastomosis comprising:

providing the surgical device according to claim **11**, inserting body tissue into the at least one holding groove, applying the pressure applying means, inserting a cutting blade into the guiding means, and transecting the body tissue with said cutting blade to form a first flush, cut end.

17. A method according to claim **16** wherein said body tissue is the vas deferens.

18. A method according to claim **16** wherein said guiding means include a first guiding groove and a second guiding groove, said step of inserting the cutting blade into the guiding means includes inserting the cutting blade into said first guiding groove, and after the step of transacting said tissue to form the first flush, cut end further including the steps of inserting the cutting blade into said second guiding groove and transacting said body tissue to form a second flush, cut end.

19. A method according to claim **18** further comprising anastomosing said first and second flush, cut ends.

20. A surgical device for compressing body tissue and guiding a cutting blade comprising:

a base member having at least one holding means for holding body tissue and first and second grooves for guiding a cutting blade substantially perpendicular to and intersecting said at least one holding means, said first and second grooves being of unequal size;

a pressure-applying member cooperating with said base member, said pressure-applying member having at least one projection adapted to atraumatically compress a portion of said body tissue held within said at least one holding means.

21. A surgical device for compressing body tissue and guiding a cutting blade comprising:

a base member having at least one holding means for holding body tissue and at least one groove oriented substantially perpendicular to and intersecting said at least one holding means for guiding a cutting blade;

a pressure-applying member cooperating with said base member, said pressure-applying member having at least one projection adapted to atraumatically compress a portion of said body tissue held within said at least one holding means, said pressure-applying member having a width less than the width of said at least one holding means such that differential compression is applied along the length of body tissue.

* * * * *

US005951587A

United States Patent [19]

Qureshi et al.

[11] Patent Number: 5,951,587

[45] Date of Patent: Sep. 14, 1999

[54] **NEEDLE HOLDER WITH SUTURE FILAMENT GRASPING ABILITIES**

[75] Inventors: **Saleem U. Qureshi**, West Chester; **Kip M. Rupp**, New Richmond; **Bennie Thompson**, Cincinnati, all of Ohio

[73] Assignee: **Ethicon-Endo-Surgery, Inc.**, Cincinnati, Ohio

[21] Appl. No.: **08/948,159**

[22] Filed: **Oct. 9, 1997**

[51] **Int. Cl.**[6] **A61B 17/28**

[52] **U.S. Cl.** **606/207**; 606/144; 606/147

[58] **Field of Search** 606/147, 148, 606/207, 206, 205, 139

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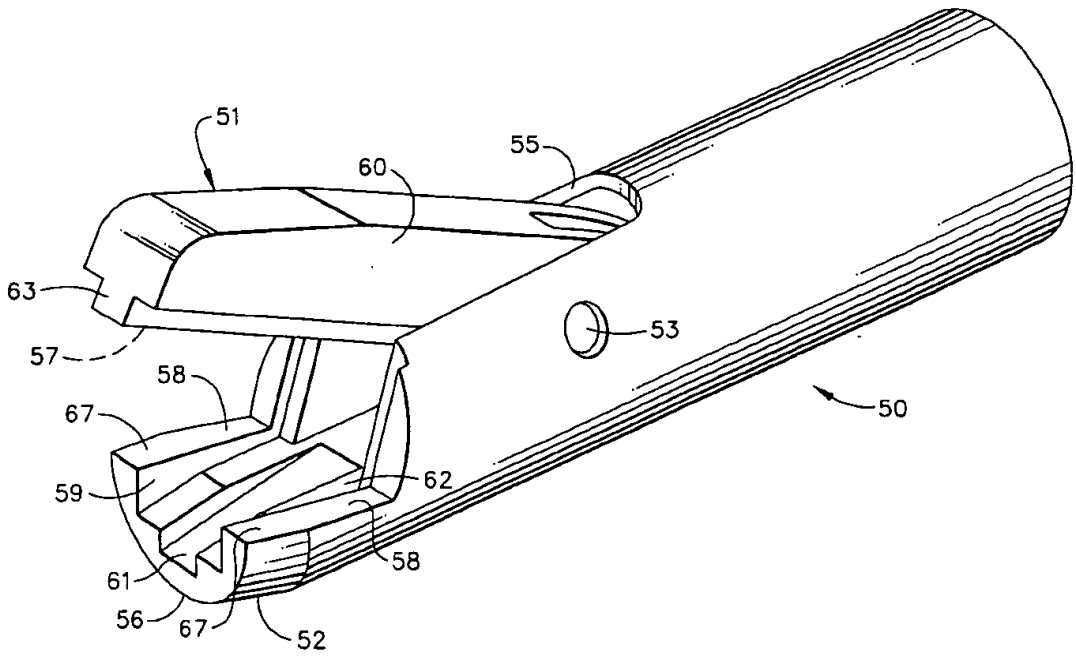
Primary Examiner—Michael Buiz
Assistant Examiner—Julian W. Woo
Attorney, Agent, or Firm—Matthew S. Goodwin

[57] **ABSTRACT**

A surgical needle holder for use in open or laparoscopic surgery, that grasps a needle or a suture filament. The needle holder has a lower jaw, and an upper jaw moveable from an open to a closed position. The lower jaw has a pair of lower jaw ledge surfaces and a groove. The upper jaw has a grasping protrusion surface that can be embedded within a groove in the lower jaw, when the upper jaw is closed. When the jaws are closed on a needle, it is grasped with a three point needle contact system. The needle contact points are the two lower jaw ledges and the upper jaw grasping protrusion surface. Closure of the jaws on a curved needle "rights" the needle. When the jaws are closed on a suture filament, the upper jaw protrusion surface and the groove form a labyrinth path that effectively grasps the suture filament relative to the end effector. This enables the surgeon to apply tension to a suture to produce a tight knot or, when proximating tissue, tension a suture loop.

6 Claims, 6 Drawing Sheets



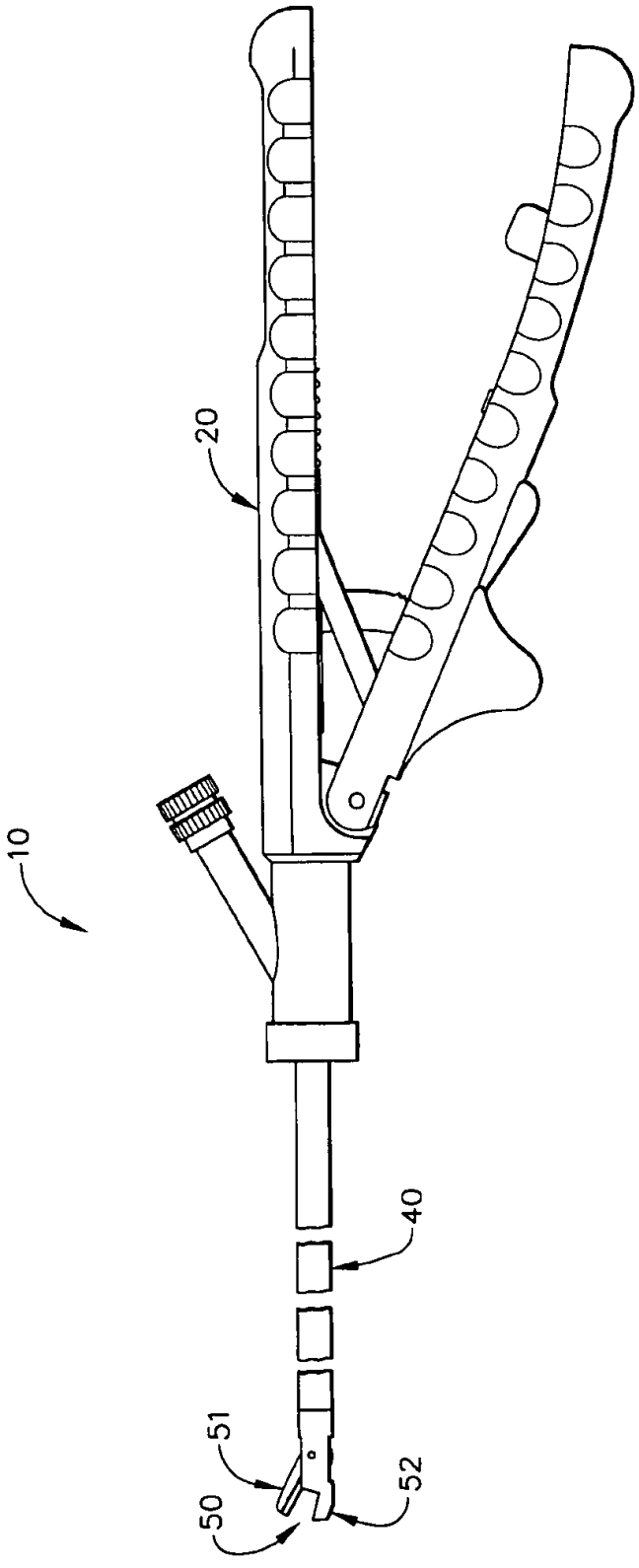


FIG. 1

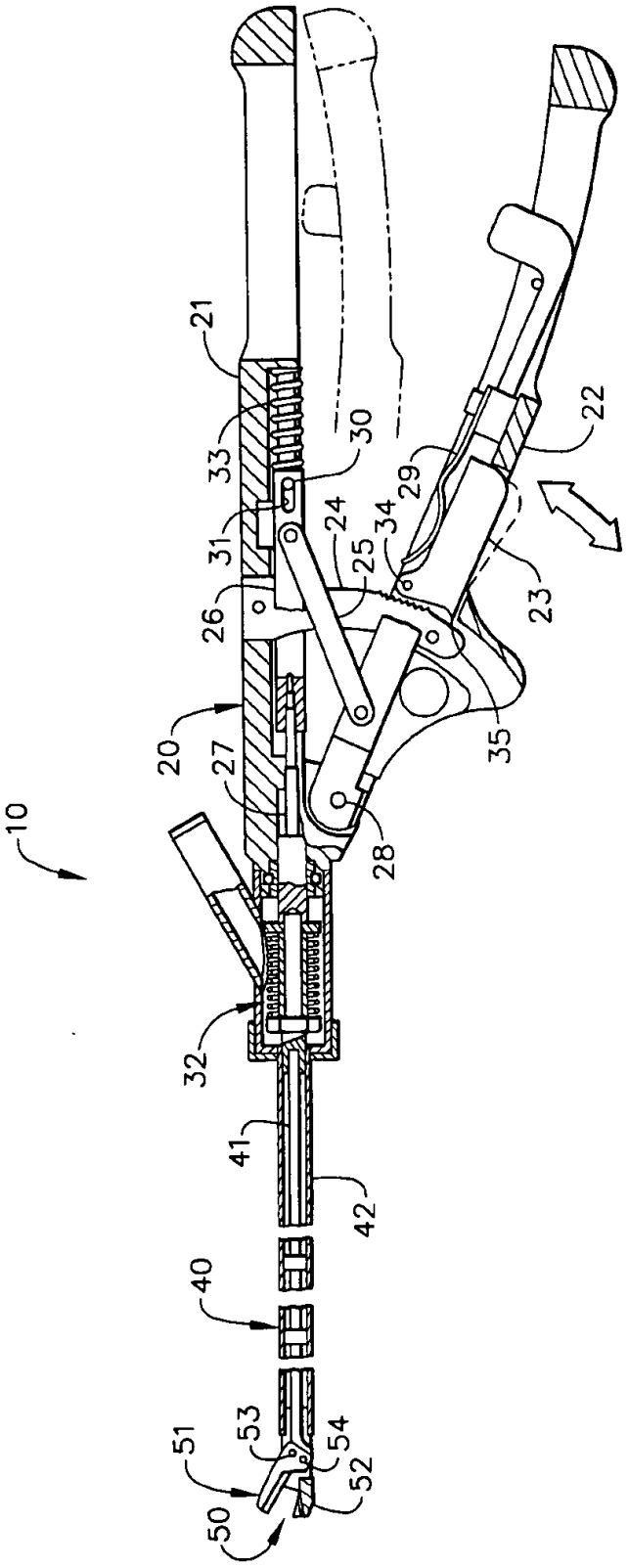

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FIG. 2

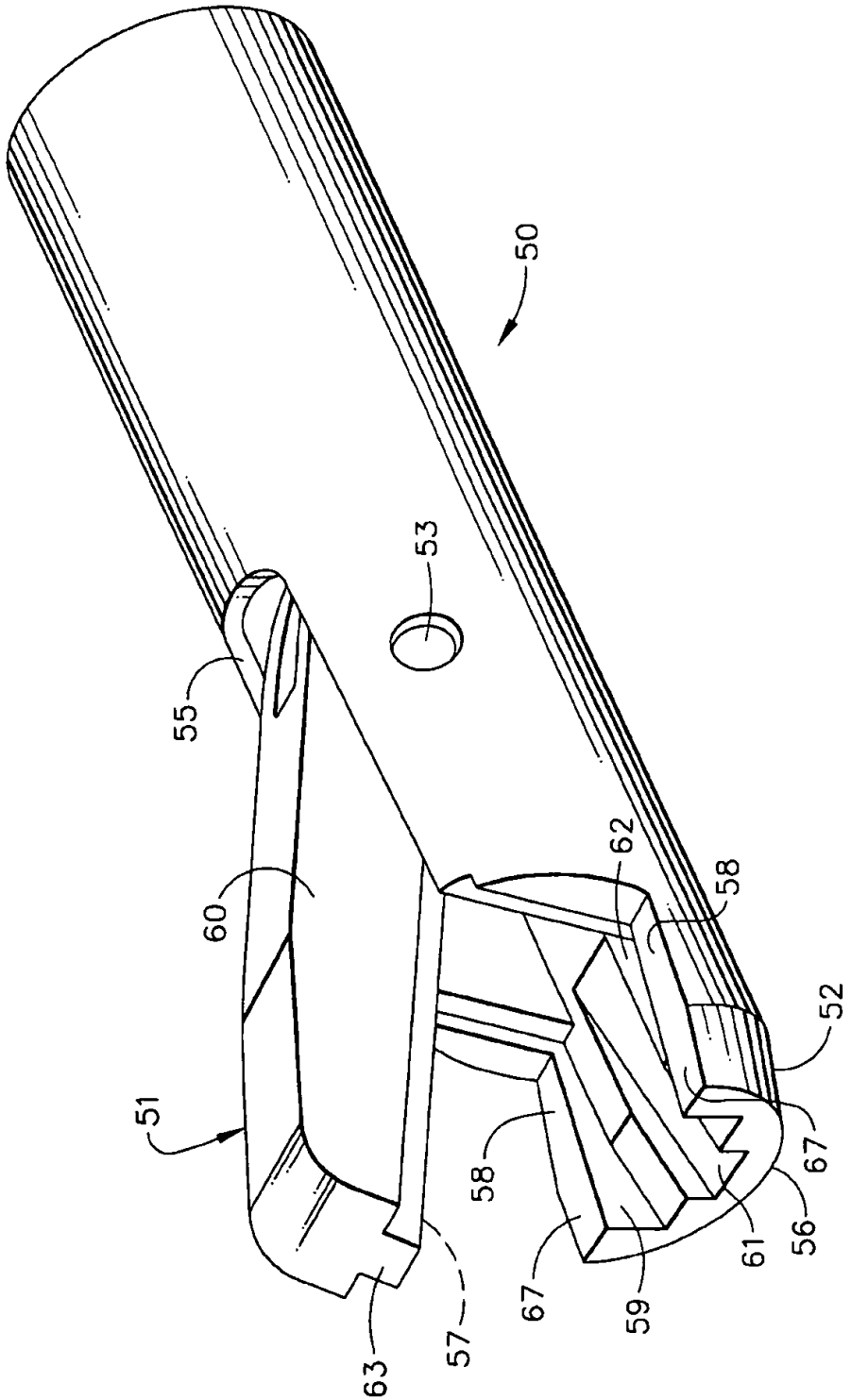

FIG. 3

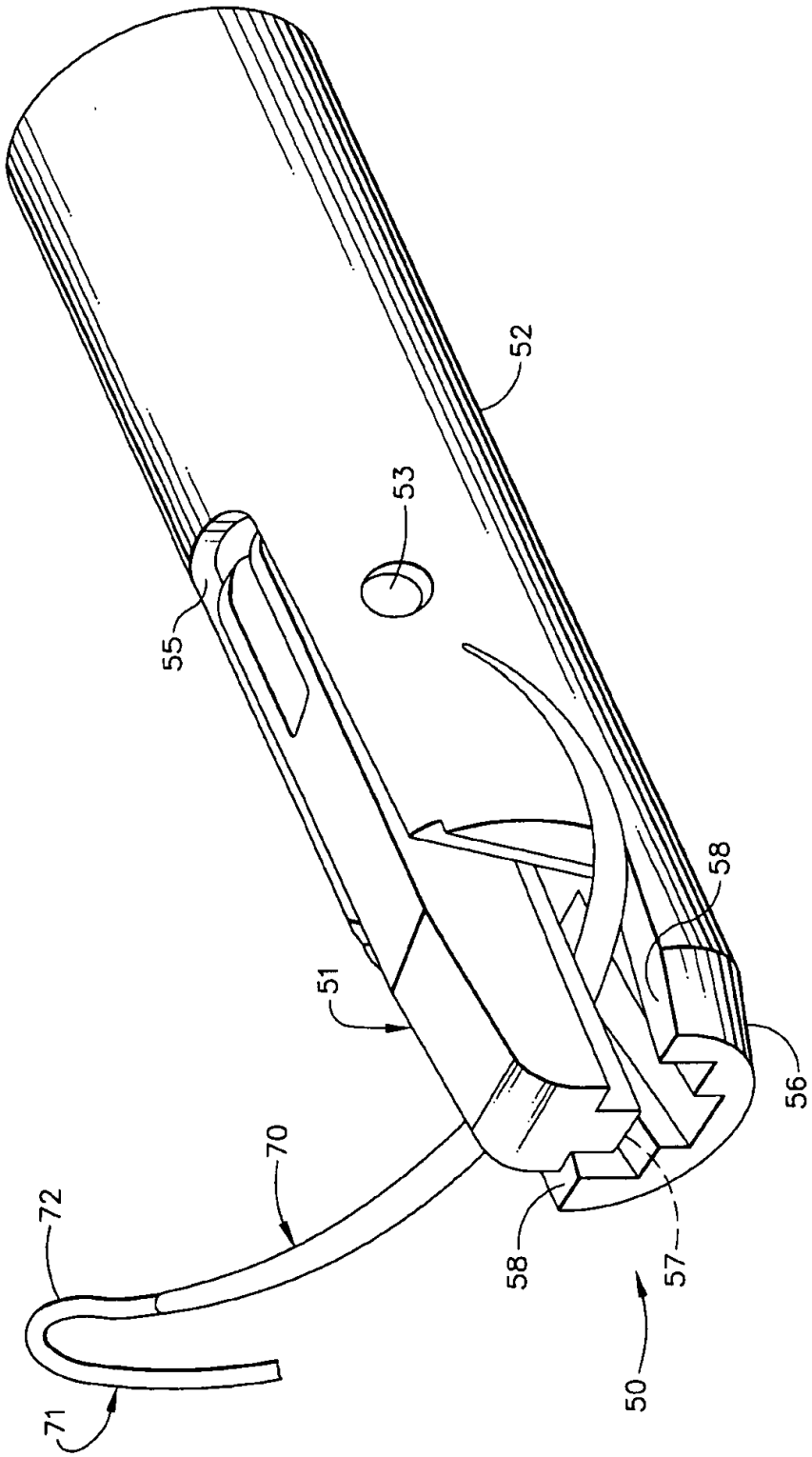

FIG. 4

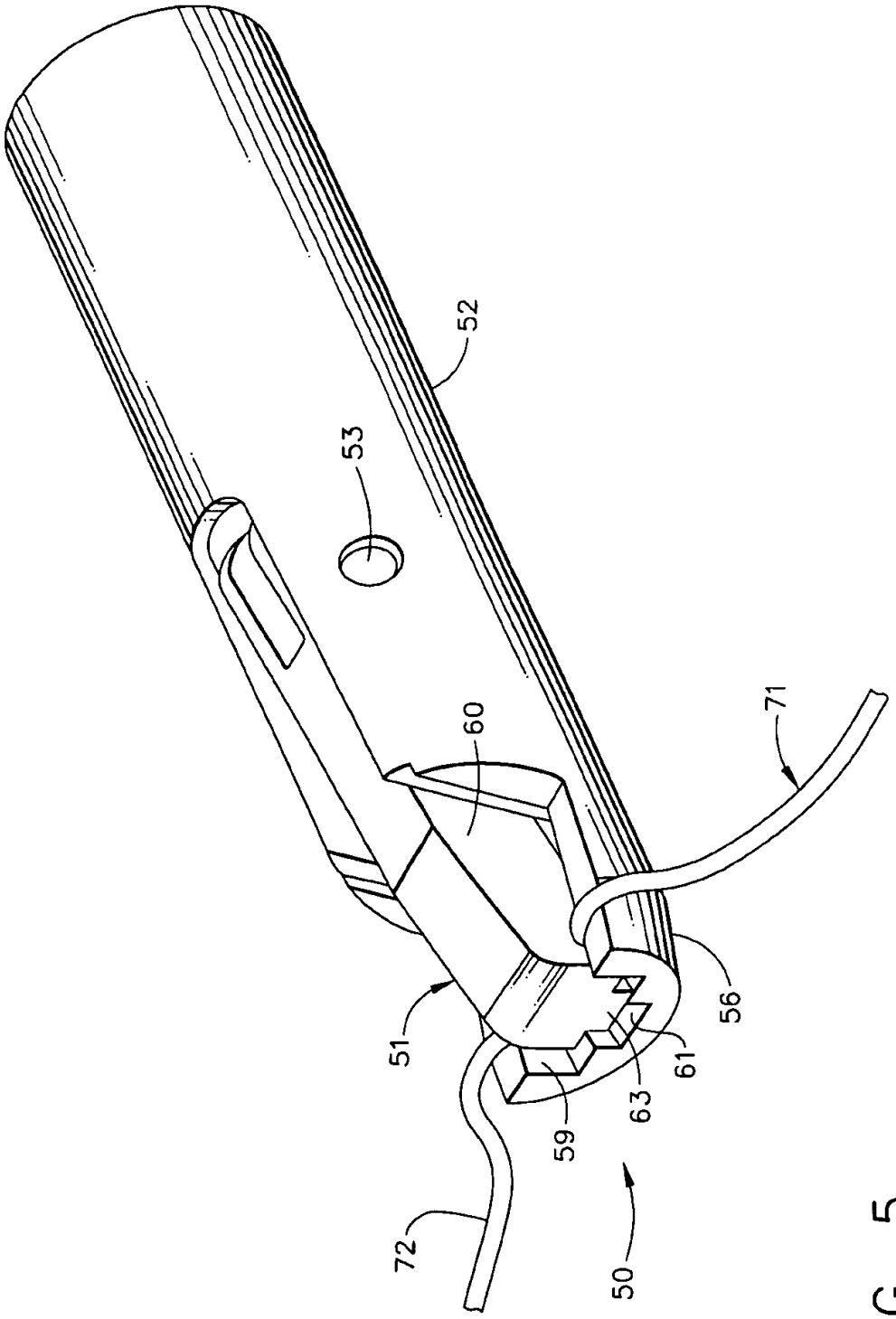

FIG. 5

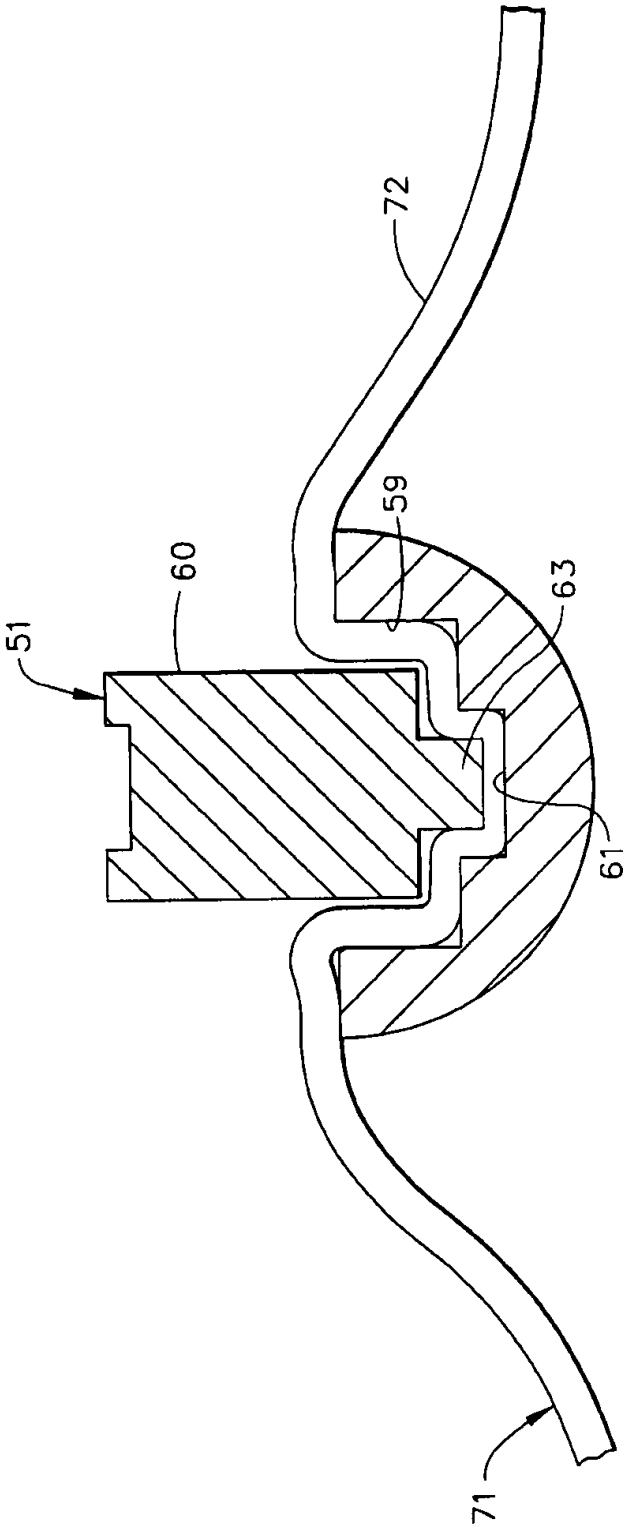

FIG. 6

NEEDLE HOLDER WITH SUTURE FILAMENT GRASPING ABILITIES

BACKGROUND

The present invention relates in general to needle holders for use in surgery, and in particular, to endoscopic needle holders with suture grasping abilities.

In endoscopic surgery, one or more needle holders are used with specialized surgical needles (wherein the needle is swaged or attached to the suture), to apply a suture to a surgical site within a patients body. Needle holders can be used in conjunction with other surgical devices such as knot deploying devices, knot tying devices, and needle driving devices. The needle holder is introduced through a cannula and is manipulated by the operator. The needle holder is generally comprised of a handle, an elongated shaft and a pair of grasping jaws. One or more jaws are moveable and are actuated by manipulation of handle controls. The jaws grasp the surgical needle and are used to manipulate the needle to produce endoscopic sutures.

Needle holders can hold or grasp various sized surgical needles at any position, proximal or distal, within the grasper jaws. For a given force input at the handle, the force exerted upon the needle by the jaw components varies as a function of the distance of the needle from the moveable jaw pivot point, and the needle diameter. The more distal the needle grasping location, the higher the forces on the needle, the bearings, and the clamping jaw. The larger the needle diameter, the higher the forces on the needle and jaw components. Thus, grasping a large diameter needle within the distal portion of the jaws could damage both the needle and instrument, or reduce the life of the instrument. It would therefore be desirable to apply a force limiting device within the needle holder to limit the amount of force applied by the grasper jaws, regardless of the position of the closure trigger, or needle diameter. Such a device is described in U.S. Pat. No. 5,413, 583 by Udo Wohlers, herein incorporated as a reference.

With the addition of a force limiting device to the needle holder, endoscopic suturing became easier and more readily accepted. However, there were still difficulties in grasping and manipulating needles in the laparoscopic environment. Control of the needle is important for endoscopic suture placement. Three distinct types of needle motion within the grasper jaws are possible, these are: 1.) needle rotation, wherein the needle point and swage rotate in unison about the grasping point; 2.) needle toggling, wherein the point and swage move, in the same plane, and in opposite directions about the grasping point; 3.) needle slippage, wherein the needle slides within the jaws and the grasping point moves closer to the tip of the needle. Additionally, it is of great value to position the needle into the needle holder in a generally transverse orientation that is suitable for placing a stitch. As described by Measamer et al. in U.S. Pat. No. 5,601,575 herein incorporated as a reference, the use of a three point needle system grasping system in conjunction with a curved needle addressed these issues. Additionally, the three point grasper design described causes the needle to "right" or snap into a position wherein the needle curvature is vertical and perpendicular to the longitudinal axis of the instrument. The "righted" needle position greatly facilitates the needle placement, but is not adequate to grasp suture.

With the breakthrough "righting" needle feature, endoscopic suturing reached a new level. However, there are still difficulties with endoscopic suturing as the needle grasper can only grasp the needle, and is not adequate to grasp suture. In endoscopic surgery, the space available within the patient is limited. Additionally, the surgical site is crowded with surgical devices such as trocar cannulas, dissectors, graspers, knot tying devices, and the like. The restricted space, when combined with a long suture, and the limited range of motion available with endoscopic access ports, can make it very difficult to tighten a stitch or knot. Thus it would be advantageous, when tying a knot or tensioning a suture loop, to grasp the suture close to the stitch or knot, rather than at the needle in connection with use of an instrument that grasps a needle.

SUMMARY OF THE INVENTION

Accordingly, the present invention is a surgical needle holder for grasping a surgical needle or a suture filament. The needle holder is comprised of a lower and an upper jaw.

The lower jaw having a pair of spaced apart lower jaw ledges, each of which has a lower jaw ledge surface. A pair of spaced apart lower floor surfaces are adjacent to the ledge surfaces. A groove is interposed between and descending from the lower floor surfaces.

The upper jaw is facing the lower jaw and has a grasping protrusion surface. The grasping protrusion surface extending downwardly from the upper jaw. The upper jaw is moveable from an open position, spaced from the lower jaw, to a closed position adjacent to the lower jaw. When the upper jaw is in the closed position, the grasping protrusion surface is embedded within and contacts the groove.

When the needle is positioned between the open lower and upper jaws, and the upper jaw is closed, the needle is grasped between the grasping protrusion surface and the lower jaw ledge surfaces.

When the suture filament is positioned between the open lower and upper jaws, and the upper jaw is closed, the suture filament is secured between the groove and the grasping protrusion surface embedded in the groove.

Significantly, the combination of a surgical needle holder with suture grasping abilities offers many advantages. The suture grasping ability enables the surgeon to grasp the suture close to the knot or stitch. Since suture stretches some linear amount per unit of length, reducing the suture length between the stitch site and the needle grasper effectively reduces the amount of suture stretch. This produces a tighter knot or stitch as more of the tensioning energy is used to tie the knot, not stretch a long suture.

Additionally, in endoscopic surgery internal space within the patient is at a premium. Using a needle driver that grasps only a needle is difficult when combined with a long suture, a confined space, and the limited range of motion from the access port. Using a needle holder that grasps the suture near the stitch or knot lessens the procedural difficulty and is a great advantage.

Another advantage of this invention is its ability to be used in conjunction with other instruments such as other needle holders, knot deployment devices, or knot tying devices. The ability to grasp the needle, or suture, or tissue will enhance the usage of these devices.

In short, the surgical needle holder of the present invention provides significant advantages to endoscopic suturing. The enhanced ability of this device to grasp surgical needles, tissue, and suture, reduces the difficulties of endoscopic suturing. Additionally, the device can be used to enhance surgical procedures in conjunction with knot tying or deployment instruments.

DETAILED DESCRIPTION OF THE DRAWINGS

The novel features of the invention are set forth with particularity in the appended claims. The invention itself,

however, both as to organization and methods of operation, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in conjunction with the accompanying drawings in which:

FIG. 1 is a side view of a surgical needle holding instrument of the present invention;

FIG. 2 is the side view of FIG. 1, wherein the instrument has been sectioned for a view of the internal components;

FIG. 3 is a perspective view of an end effector of the instrument with a fixed lower jaw and an open upper jaw;

FIG. 4 is the perspective view of FIG. 3 with a surgical needle grasped within the jaws of the end effector;

FIG. 5 is the perspective view of FIG. 3 with a suture filament grasped within the jaws of the end effector; and

FIG. 6 is a section view of FIG. 5 wherein the suture is firmly grasped within the jaws of the instrument showing the labyrinth path of the suture filament.

DETAILED DESCRIPTION OF THE INVENTION

As best shown in FIG. 1, the present invention is a surgical needle holder **10**, utilized for endoscopic or open surgical procedures. The needle holder **10** comprises a proximal handle **20**, an elongated shaft **40**, and a distal end effector **50**. The distal end of the device **10** is comprised of a fixed lower jaw **52** and a moveable upper jaw **51**. The upper jaw **51** of the end effector **50**, is moveable from a first open position to a second position to effectively grasp a needle, tissue, or surgical suture. The elongated shaft **40** and end effector **50** are insertable through a cannula for endoscopic surgery.

Referring now to the instrument cross section as shown in FIG. 2, with the exception of the distal end effector **50**, the instrument is generally disclosed in the Wohlers U.S. Pat. No. 5,413,583, which is incorporated by reference. As described in this patent, the shape of the handle or grip arrangement can vary and still meet design intent.

The handle consists of a body **21** and a generally rectangular elongate trigger **22**. The handle trigger **22** is pivotally mounted to the handle body **21**, about handle pin **28**. Closure of the handle trigger **22**, towards the handle body **21**, results in proximal motion of the handle block **26**, compression of the return spring **33**, closure of the jaws at the distal end of the instrument, and engagement of a one way ratchet mechanism. Trigger release pawl **24** is shown in engaged position.

The ratchet mechanism subassembly holds the jaws firmly closed to constrain the needle. The ratchet mechanism is comprised of trigger release pawl **23**, ratchet plate **24**, pawl pivot pin **34**, and pawl spring **29**. Depression of the trigger release pawl **23** inwardly see (FIG. 2) releases the pawl tooth **35**, located on the trigger release pawl **23**, from the ratchet plate **24** and the return spring **33** biases the trigger **23** and jaws open, releasing the needle **70** or suture filament **72**.

Handle trigger **22** is coupled to the generally rectangular elongate handle block **26** by one or more trigger links **25**. Inward movement of the trigger **23** is transmitted by trigger links **25** and results in proximal longitudinal motion of the handle block **26** and compression of the return spring **33**. The handle block **26** is moveably coupled, in the longitudinal direction, to the handle body **21**, by block pin **30** in block slot **31**. The handle block **26** is fixably coupled to the proximal shaft **27**. Proximal shaft **27** is coupled to the proximal end of actuation shaft **41** by a force limiting coupling **32** as described in the Wohlers patent listed above. This coupling limits the amount of force that can be applied by the upper jaw **51** In the Wohlers device, a series of compressible springs are used as the force limiting device.

The actuation shaft **41** is slideably and concentrically mounted within the bore running longitudinally in the exterior shaft **42**. The proximal end of the exterior shaft **42**, is fixably mounted to the distal end of the handle **20**. The distal end of the exterior shaft **42** is fixably mounted to the proximal end of the lower jaw **51**.

As shown in FIGS. **1** through **6**, the lower jaw **52** is generally cylindrical in shape with a channel running longitudinally within. A generally "L" shaped upper jaw **51** (see FIG. **2**) is pivotally mounted within upper slot **55** of the lower jaw **52**, about jaw pivot pin **53** (see FIG. 3). The lower end of the upper jaw **51** is hingeably connected to the actuation shaft **41** by actuation shaft pin **54** as shown in FIG. **2**. Proximal movement of the actuation shaft **41** results in upper jaw **51** pivoting closed about pivot pin **53**. A grasping protrusion **63** lies along the longitudinal axis and extends inwardly from a pair of spaced-apart inner surface **65** of the upper jaw **51** (see FIG. 3). Upper jaw grasping protrusion surface **57** is located on the inward side of the grasping protrusion **63**. A grasping protrusion **63** lies along the longitudinal axis and extends inwardly from a pair of upper floor surfaces **51** (see FIG. 3). Upper jaw grasping surface **57** is located on the inward side of the grasping blade **53**.

A "U" shaped channel **56**, extends distally from the proximal end of the lower jaw **52**. This channel provides two lower jaw ledge surfaces **58** located on the spaced-apart lower jaw ledges **67**. When closed, the upper jaw **51** pivots within the "U" shaped channel **56** and the grasping protrusion surface **57** is embedded in and contacts the groove **61**. Clearance is supplied between the inner ledge surfaces **59** and the outer jaw surfaces **60** of the upper jaw **51** (see FIGS. **5** and **6**).

As shown in FIG. **4**, a surgical needle **70** is captured within the distal jaws of the needle holder. The needle **70**, is constrained by three discreet contact points comprised of the lower jaw ledge surfaces **58** and the upper jaw grasping protrusion surface **57**. As disclosed by Measamer et al. in U.S. Pat. No. 5,601,575, which is herein incorporated for reference, this geometry causes the needle **70** to "right" or snap to a position wherein the plane of the curvature of the needle is vertical and perpendicular to the longitudinal axis of the instrument (see FIG. 4). Thus, the jaws of the present invention incorporate the "self righting" needle feature.

Referring now to FIG. **3**, a groove **61** is located between and descends from the floor surfaces **62** of the "U" channel **56**. The groove **61** is angled for parallel closure with upper jaw grasping protrusion surface **57** when the upper jaw **51** is fully closed. When fully closed, with no object within the jaws, the grasping protrusion **63** ,of the upper jaw **51**, resides within the groove **61** with the upper jaw grasping protrusion surface **57** in contact with the floor of the inner groove **61**.

As shown in FIGS. **5** and **6**, when the upper jaw **51** is closed on suture filament **72**, the groove **61**, in combination with the grasping protrusion **63** on the upper jaw **51**, form a labyrinth path (see FIG. **6**.) that effectively grasps the suture filament **72**. The labrynth path constrains the suture filament **72** relative to the end effector **50** and enables the surgeon to apply tension to produce a tight knot, or tension a suture loop when proximating tissue. Such a feature is of value in surgery where knot security is of great importance. Additionally, the upper and lower jaws can be used to effectively grasp and manipulate tissue.

Whereas the preferred invention utilizes a labyrinth path design to grasp suture, it should be obvious to one skilled in

the art that a variety of paths are available to enable a needle holder to grasp suture.

While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. Whereas the invention is described for use during endoscopic surgery, it is apparent that the invention can be used for open or general surgery. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.

What is claimed is:

1. A surgical needle holder for grasping a surgical needle or a suture filament, said needle holder comprising:

a lower jaw having:

i) a pair of spaced-apart lower jaw ledges, each of said ledges having a lower jaw ledge surface thereon,

ii) a pair of spaced-apart lower floor surfaces adjacent said ledge surfaces, and

iii) a groove interposed between and descending from said lower floor surfaces, said groove being sloped downwardly from a proximal end of said lower jaw to a distal end of said lower jaw; and

an upper jaw facing said lower jaw, said upper jaw having a grasping protrusion surface from said upper jaw, said upper jaw moveable from an open position spaced from said lower jaw to a closed position adjacent to said lower jaw, and when said upper jaw is in said closed position, said grasping protrusion surface is embedded in and contacts said groove;

wherein when said needle is positioned between said lower and upper jaws in the open position, and said upper jaw is moved to the closed position, said needle is grasped between said grasping protrusion surface and said lower jaw ledge surfaces; and

wherein when said suture filament is positioned between said lower and said upper jaws in the open position, and said upper jaw is moved to the closed position, said suture filament is secured between said groove and said grasping protrusion surface embedded in said groove.

2. The needle holder of claim 1 wherein said upper jaw has a pair of spaced-apart upper floor surfaces, said grasping protrusion surface is interposed between and extends downwardly from said upper floor surfaces, and when said upper jaw is in said closed position, said pair of upper floor surfaces are adjacent said pair of lower floor surfaces.

3. The needle holder of claim 2 further comprising a handle assembly for moving the upper jaw from the open position to the closed position, and a shaft coupling said lower and upper jaws to said handle assembly.

4. The needle holder of claim 3 wherein said handle assembly has a force limiting coupling therein for limiting the grasping force to said jaws when said upper jaw is moved from its open to closed positions.

5. The needle holder of claim 4 wherein said upper jaw is pivotally attached to said shaft.

6. The needle holder of claim 5 wherein each of said lower jaw ledges has an inner ledge surface extending from said ledge surface to said lower floor surface, said upper jaw has a top surface thereon and a pair of spaced-apart outer jaw surfaces, each of said outer jaw surfaces extending from said top surface to said upper floor surface;

wherein when said suture filament is secured between said groove and said grasping protrusion surface embedded in said groove, said suture filament is interposed between said inner ledge surfaces of said lower jaw ledges and said outer jaw surfaces of said upper jaw.

* * * * *

US005797958A

United States Patent [19]

Yoon

[11] Patent Number: 5,797,958

[45] Date of Patent: Aug. 25, 1998

[54] **ENDOSCOPIC GRASPING INSTRUMENT WITH SCISSORS**

[76] Inventor: **InBae Yoon**, 2101 Highland Ridge Dr., Phoenix, Md. 21131

[21] Appl. No.: **760,245**

[22] Filed: **Dec. 4, 1996**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 612,634, Mar. 6, 1996, and Ser. No. 376,186, Jan. 20, 1995, Pat. No. 5,665,100, which is a continuation-in-part of Ser. No. 281,814, Jul. 28, 1994, abandoned, which is a continuation of Ser. No. 73,193, Jun. 8, 1993, Pat. No. 5,334,209, which is a continuation of Ser. No. 720,381, Jun. 25, 1991, Pat. No. 5,217,473, which is a division of Ser. No. 446,555, Dec. 5, 1989, Pat. No. 5,026,379, said Ser. No. 612,634, is a continuation of Ser. No. 281,814.

[51] **Int. Cl.**[6] **A61B 17/04**

[52] **U.S. Cl.** **606/207**; 606/139; 606/140; 606/170

[58] **Field of Search** 606/144–148, 606/139, 170, 157, 158

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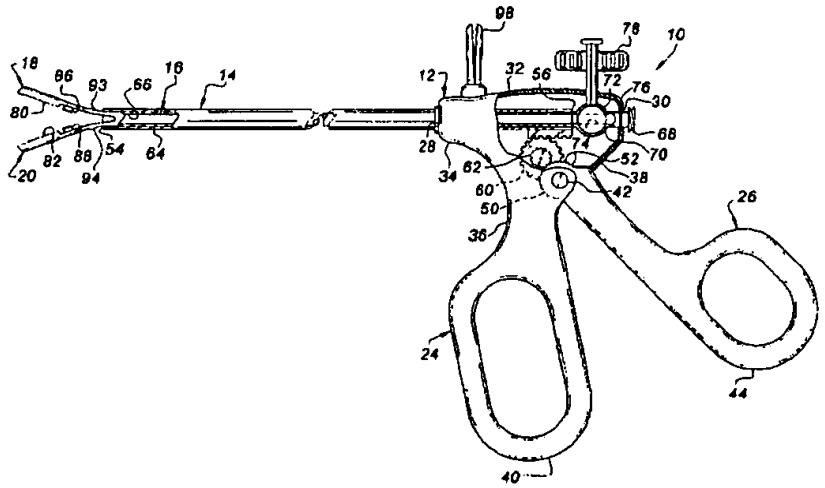
[57] **ABSTRACT**

A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity includes a handle and an elongate tubular member having a proximal end coupled with the handle for being disposed externally of the anatomical cavity and a distal end for being disposed within the anatomical cavity and carrying a pair of opposed, relatively movable jaws. The jaws are operable by manipulation of the handle to grasp objects, such as needles, and to cut tissue. In addition, the elongate tubular member defines a channel permitting fluids and other instruments to be communicated at the operative site without the need of having to remove the endoscopic instrument from the body.

18 Claims, 5 Drawing Sheets



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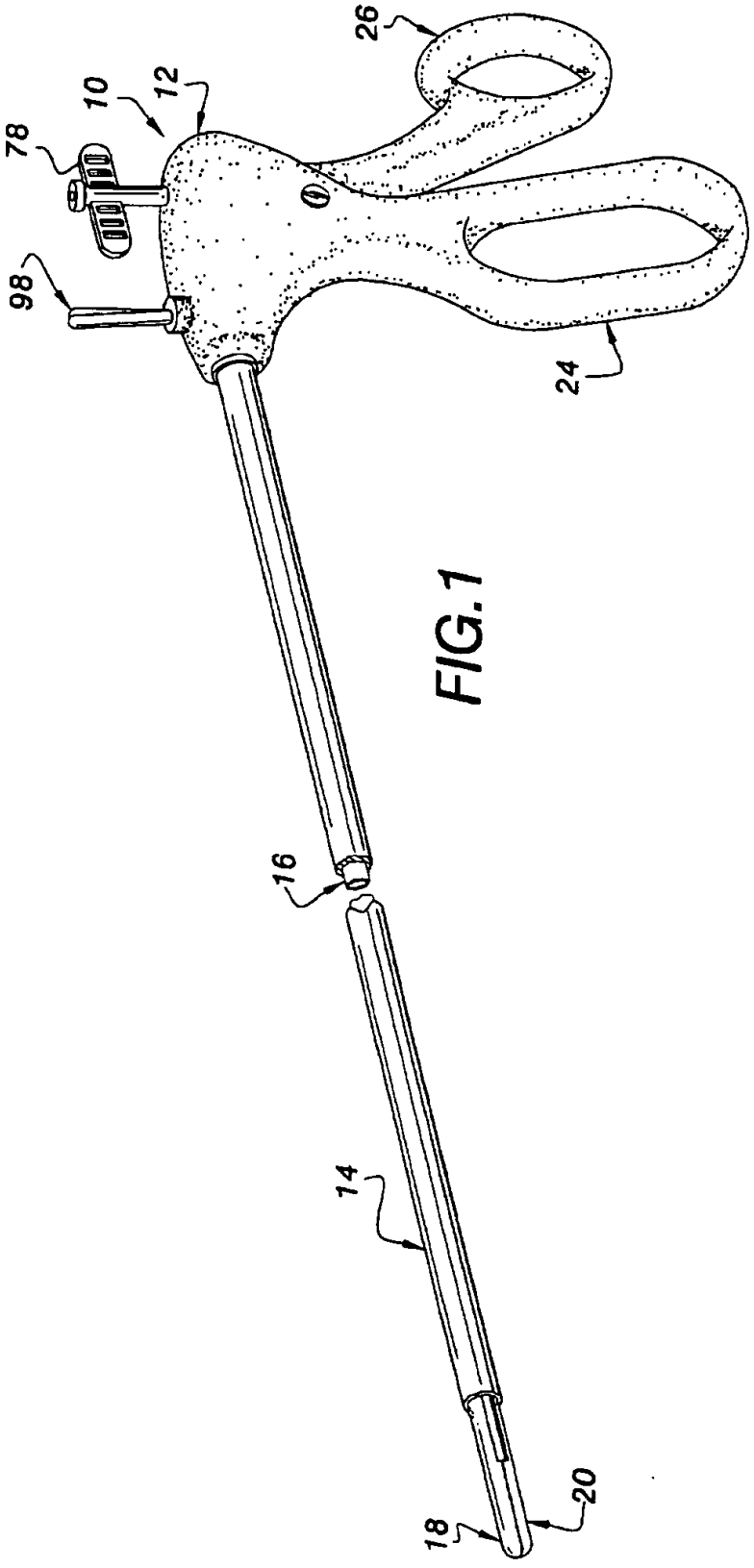

FIG.1

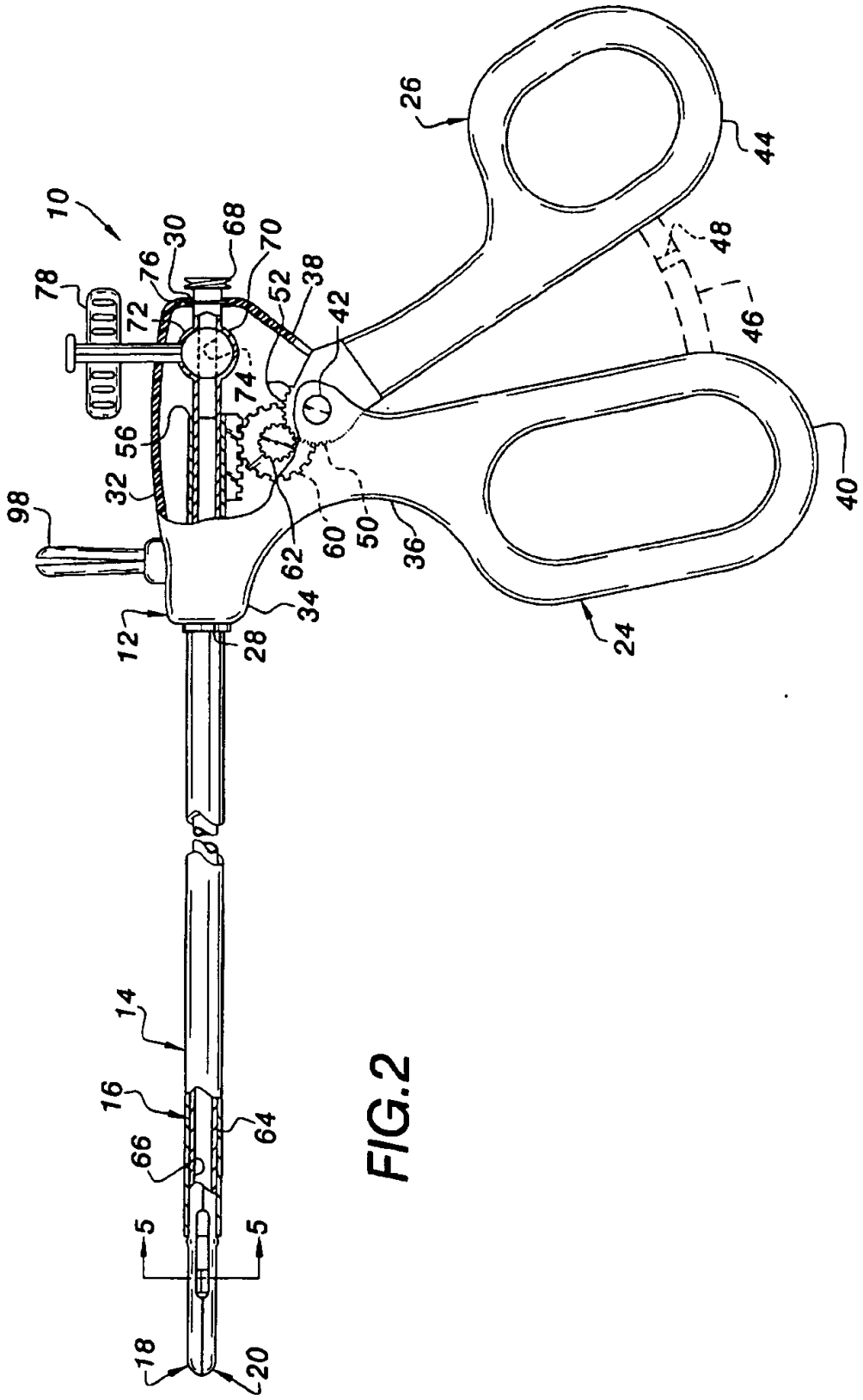
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FIG.2

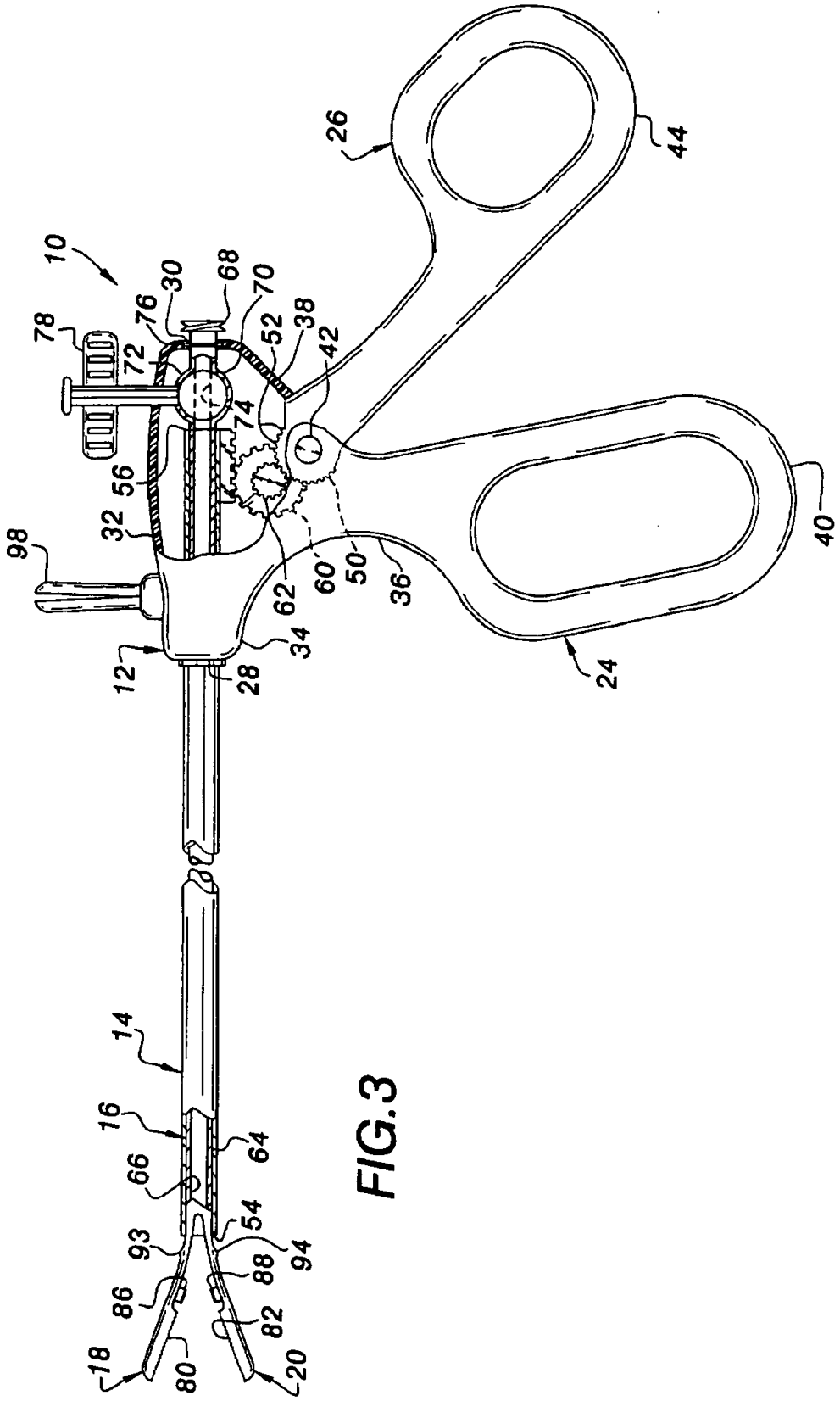
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FIG.3

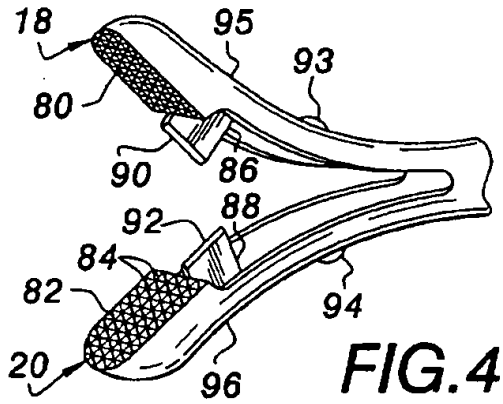

FIG.4

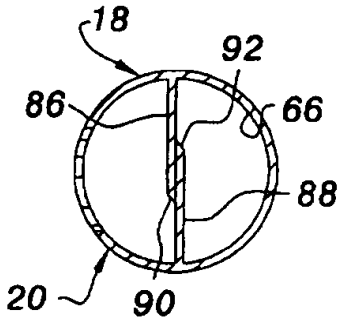

FIG.5

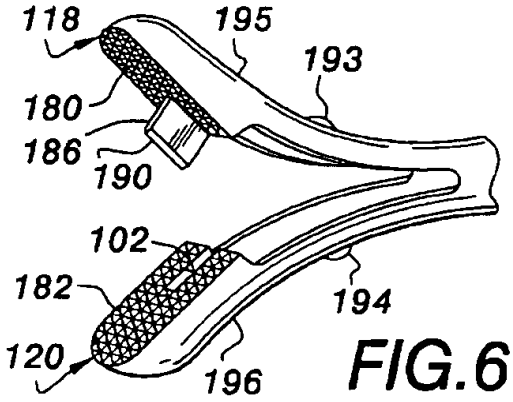

FIG.6

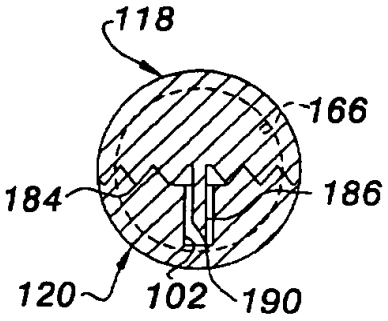

FIG.7

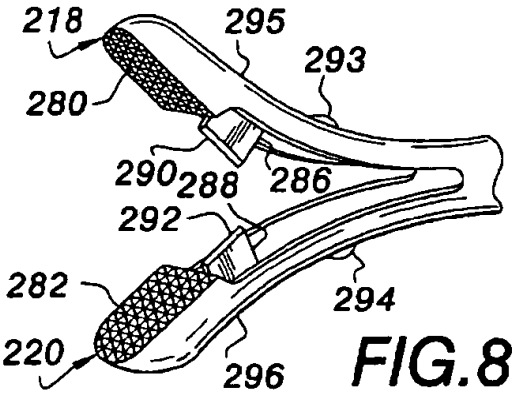

FIG.8

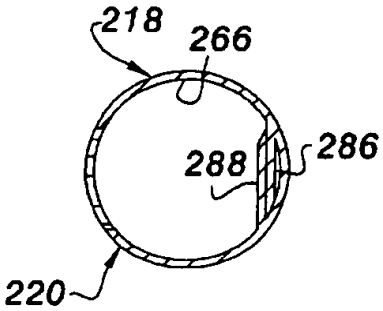

FIG.9

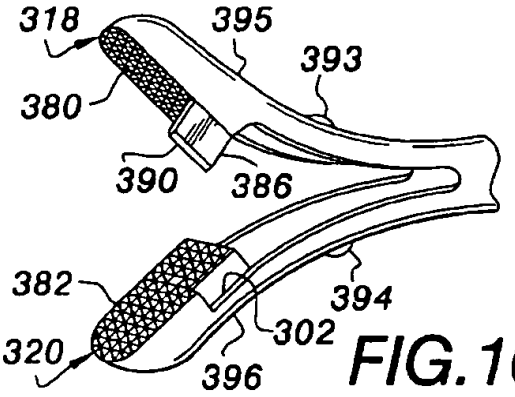

FIG.10

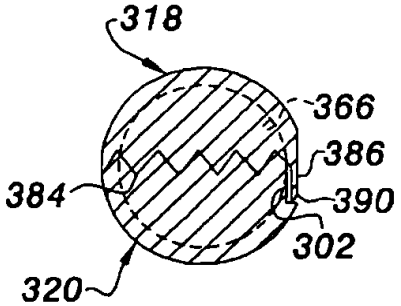

FIG.11

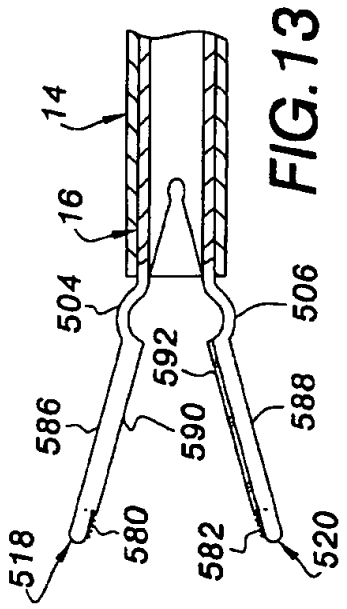

FIG.13

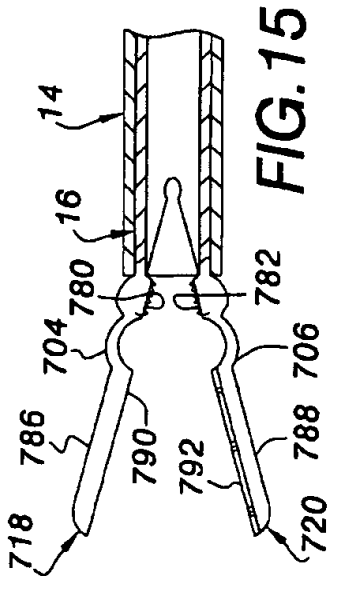

FIG.15

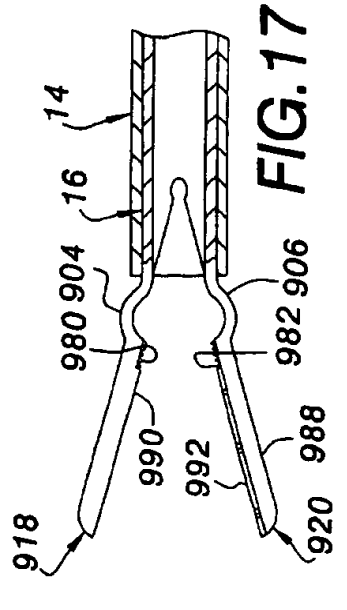

FIG.17

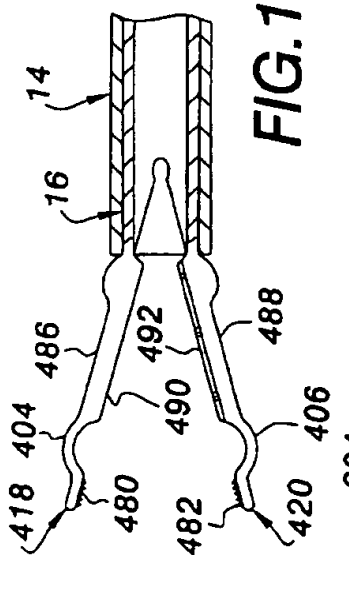

FIG.12

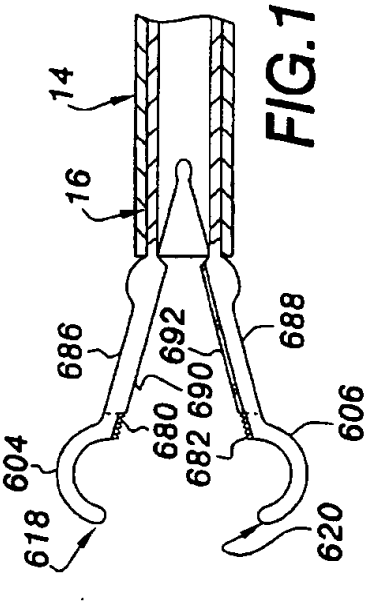

FIG.14

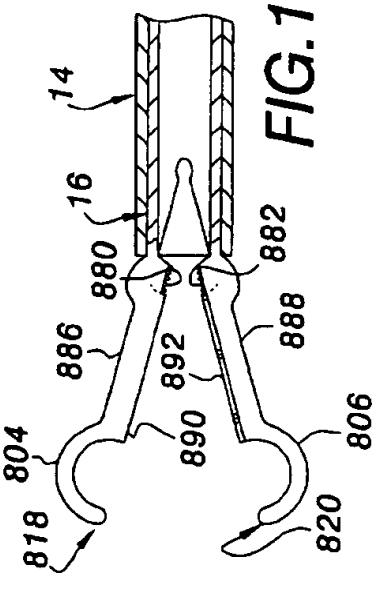

FIG.16

ENDOSCOPIC GRASPING INSTRUMENT WITH SCISSORS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of applicant's patent applications Ser. No. 08/612,634, filed Mar. 6, 1996, pending and Ser. No. 08/376,186, filed Jan. 20, 1995, now U.S. Pat. No. 5,665,100, which are a continuation and a continuation-in-part, respectively, of patent application Ser. No. 08/281,814, filed Jul. 28, 1994, now abandoned, which is a continuation of patent application Ser. No. 08/073,193, filed Jun. 8, 1993, now U.S. Pat. No. 5,334,209, which is a continuation of patent application Ser. No. 07/720,381, filed Jun. 25, 1991, now U.S. Pat. No. 5,217,473, which is a division of patent application Ser. No. 07/446,555, filed Dec. 5, 1989, now U.S. Pat. No. 5,026,379, the disclosures of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to medical procedures and instruments and, more particularly, to a multifunctional endoscopic grasping instrument with scissors.

2. Discussion of the Related Art

Endoscopic and minimally invasive medical procedures, such as laparoscopy, have become widely accepted for surgery and diagnosis due to the associated advantages relating to reduced trauma and hospitalization time. The performance of an endoscopic procedure typically involves creation of one or more puncture sites through a wall of an anatomical cavity using a penetrating instrument including an obturator, such as a trocar, disposed within a portal sleeve. After the penetrating instrument has penetrated into the anatomical cavity, the obturator is withdrawn leaving the sleeve in place to form a portal in the cavity wall for the introduction of instruments such as endoscopes, ligating appliers, forceps, cauteries and the like into the anatomical cavity.

Endoscopic procedures commonly involve performing a number of individual acts or functions within the anatomical cavity including grasping, cutting, coagulating, irrigating, aspirating, puncturing, injecting, dissecting, cauterizing, ligating, suturing, illuminating, visualizing and/or collecting specimens for biopsy. However, most endoscopic instruments are designed to perform only one of the above functions, requiring several incisions for placement of multiple portal sleeves to accommodate a suitable number of endoscopic instruments for performing the required functions or necessitating frequent withdrawal and replacement of individual endoscopic instruments through a single incision. While it is generally desirable to minimize the number of incisions created for performing a particular endoscopic procedure, substitution of instruments through a single incision can be time consuming, depending on the efficiency of the medical facility and staff, increasing the period of anesthetization for the patient. Additionally, internal bleeding can develop during the substitution of instruments thereby obscuring the field of view and requiring time consuming clean-up procedures to be performed.

A disadvantage of endoscopic instruments having articulated jaws, in particular, is that the jaws are typically mounted on pivots at the distal end of relatively long shafts requiring complicated and space-consuming linkages for converting the user's proximal movements into motion of the jaws increasing the risk of fluid leaking through poorly sealed pivotal mounts.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to overcome the above-mentioned disadvantages of the prior art with an endoscopic instrument capable of performing multiple functions.

Another object of the present invention is to permit multiple functions to be performed with a single endoscopic instrument while defining a channel through the instrument for other instruments and/or fluids to be introduced at the operative site so that other functions can be performed without the need of having to remove the endoscopic instrument from the body.

Some of the advantages of the present invention over the prior art are that the endoscopic instrument can perform multiple functions through a single incision thereby minimizing the number of incisions required to perform an endoscopic procedure, that the frequency of substitution of instruments through a single incision can be reduced, that visualization of tissue through an operating channel formed through the instrument permits grasping and cutting operations to be performed with greater precision, that conventional handle structures can be used to provide users with a familiar feel and to decrease adaptation time, that the instrument can be fabricated at low cost using simple mechanisms without complicated linkages, and that the instrument can be sterilized for reuse or disposable for single patient use as desired.

These and other objects, advantages and benefits are realized with the present invention as generally characterized in an endoscopic instrument including a handle and an elongate tubular member having a proximal end coupled with the handle for being disposed externally of the anatomical cavity and a distal end for being disposed within the anatomical cavity and carrying a pair of opposed, relatively movable jaws. The jaws are operable by manipulation of the handle to perform multiple functions such as, for example, grasping objects such as needles and cutting tissue. In addition, the elongate tubular member defines a channel providing access to the operative site from outside the anatomical cavity without the need of having to remove the instrument from the cavity.

Other objects and advantages of the present invention will become apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings, wherein like parts in each of the several figures are identified by the same reference numerals or by reference numerals having the same last two digits.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view, broken longitudinally, of an endoscopic instrument according to the present invention.

FIG. 2 is a broken side view, partly in section, of the endoscopic instrument of FIG. 1 with jaws of the instrument in a closed position.

FIG. 3 is a broken side view, partly in section, of the endoscopic instrument of FIG. 1 with the jaws of the instrument in an open position.

FIG. 4 is a fragmentary perspective view of the distal end of the endoscopic instrument of FIG. 1 with the jaws of the instrument in the open position.

FIG. 5 is a cross-sectional view of the instrument jaws taken through line 5—5 in FIG. 2.

FIG. 6 is a fragmentary perspective view of the distal end of a modification of the endoscopic instrument according to the present invention with the jaws of the instrument in an open position.

FIG. 7 is a cross-sectional view of the jaws of the endoscopic instrument of FIG. 6 in a closed position.

FIG. 8 is a fragmentary perspective view of the distal end of another modification of the endoscopic instrument according to the present invention with the jaws of the instrument in an open position.

FIG. 9 is a cross-sectional view of the jaws of the endoscopic instrument of FIG. 8 in a closed position.

FIG. 10 is a fragmentary perspective view of the distal end of yet another modification of the endoscopic instrument according to the present invention with the jaws of the instrument in an open position.

FIG. 11 is a cross-sectional view of the jaws of the endoscopic instrument of FIG. 10 in a closed position.

FIGS. 12–17 are fragmentary side views, partly in section, of further modifications of the instrument jaws according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The endoscopic instrument of the present invention can be utilized in any type of anatomical cavity; and, accordingly, while the instrument is described hereinafter for use with a portal sleeve in endoscopic procedures, such as laparoscopy, the instrument can be used with catheters and other small or large diameter tubular or hollow, cylindrical members providing access to small cavities, such as veins and arteries as well as large cavities, such as the abdomen.

An endoscopic instrument **10** in accordance with the present invention, as illustrated in FIGS. **1** and **2**, includes a housing **12**, an outer tubular member **14** extending distally from the housing **12**, an inner tubular member **16** telescopically fitted within the outer tubular member and terminating distally in a pair of opposed jaws **18** and **20**, and a handle portion formed of a fixed handle **24** and a movable handle **26**.

Housing **12** includes longitudinally spaced front and rear walls **28** and **30** oriented perpendicular to a longitudinal axis of the instrument, a top wall **32** substantially parallel to the longitudinal axis and a bottom wall **34** having a concave forward portion **36** curving downwardly from the front wall to connect with an upper end of fixed handle **24** and a rearward portion **38** extending proximally at an angle relative to the longitudinal axis of the instrument from an upper end of the handle **24** to rear wall **30**. A lower end of the fixed handle is configured as an elongate finger loop **40** to accommodate one or more fingers of a user. Movable handle **26** is pivotally mounted on a pin **42** proximally spaced from fixed handle **24** and secured internally to a wall or walls of the housing. A lower end of the handle **26** is configured as a finger loop **44** to accommodate one or more fingers of the user, and a pair of arcuate mating protrusions, shown by broken lines at **46** and **48** in FIG. **2**, can optionally be carried in opposed relation on finger loops **40** and **44** for ratcheting engagement during operational use. Movable handle **26** includes an arcuate end portion **50** disposed within housing **12** and defining a plurality of gear teeth **52** on a side of pin **42** opposite finger loop **44**.

Outer tubular member **14** is open at both ends and extends distally from housing **12** through an opening in the front wall **28** of the housing. Distal end **54** of outer tubular member **14** can be blunt as shown, tapered, beveled, slotted or chamfered as desired or have any other suitable distal configuration. Preferably, outer tubular member **14** is made of a cylindrical length of a substantially rigid material, such as stainless steel or other medically acceptable metal or plastic materials. The proximal end **56** of the outer tubular member is movably disposed within the housing and carries a rack **58** in spaced relation to the toothed end portion **50** of handle **26**. A pinion gear **60** engages the rack **58** and is mounted on the same shaft as a reduction gear **62** which meshingly engages toothed end portion **50** of the handle to convert relatively small rotary or pivotal movement of the handle into significantly larger linear movement of the rack. Looking at FIGS. **2** and **3**, it will be appreciated that counterclockwise rotation of handle **26** about pin **42** results in proximal movement of outer tubular member **14** relative to housing **12** and that clockwise rotation of handle **26** about pin **42** results in distal movement of outer tubular member **14** relative to housing **12**. In a preferred embodiment, movable handle **26** is biased in a clockwise direction toward fixed handle **24**, for example by use of a torsion spring (not shown) coiled around pin **42** and connected between the movable handle and the fixed handle and/or the housing.

Inner member **16** includes a tubular portion **64** telescopically fitted within outer tubular member **14** and defining a lumen or channel **66** through the instrument. The proximal end of the inner member extends through the rear wall of housing **12** and terminates at a coupling **68**, for example a Luer lock, for connection with sources of fluid or suction, other medical instruments and operating units such as those shown and described in my pending application Ser. No. 08/376,186, the disclosure of which has been incorporated herein by reference. A hollow, spherically-shaped valve housing **70** is distally spaced from the coupling within the housing, and a spherical valve member **72** having a cylindrical aperture or passage **74** formed therethrough is rotatably disposed within the valve housing and connected with a knob **78** extending upwardly through an opening in the top wall of the housing to permit manual operation of the valve from outside the housing. The inner member is fixed relative to the housing with a flange **76** mounted between the coupling and the valve and received within a slotted recess formed in rear wall **30**. The distal end of tubular portion **64** is bifurcated or split longitudinally to form integral one-piece jaws **18** and **20** in opposed relation, the jaws being normally biased apart as shown in FIGS. **3** and **4**. Referring to FIG. **4**, in particular, jaws **18** and **20** cooperate to define a grasping portion at a distal end having opposed inner surfaces **80** and **82** formed with conventional diamond-shaped protrusions or teeth **84** for securely holding a suture needle, anatomical tissue or any other useful object when closed and a cutting portion proximally spaced from the grasping portion and including a pair of cutting members or blades **86** and **88** carried by the jaws in opposed relation. As best seen in FIGS. **4** and **5**, blades **86** and **88** are proximally spaced from grasping surfaces **80** and **82** and are mounted to project inwardly along a central longitudinal axis of each jaw in generally opposed relation so that sharp tissue cutting edges **90** and **92** of the blades slidingly engage one another like a scissors when the jaws are moved between the closed position or condition shown in FIG. **2** and the open position or condition shown in FIG. **3**. The blades are shown oriented parallel to a longitudinal axis of the inner tubular member but can be oriented at any angle relative to the longitudinal axis dependent upon procedural use. Wedge-like cams **93** and **94** protrude outwardly from respective outer surfaces **95** and **96** of jaws **18** and **20** and taper inwardly in the proximal

direction to present an angled cam surface against which the distal end of outer tubular member **14** can act to force the jaws together.

Tubular body **64** of the intermediate member is preferably formed with jaws **18** and **20** as a single unitary part using a resilient medically-acceptable material such as, for example, a spring steel or a plastic material having suitable elastic properties for normally biasing the upper and lower jaws apart while permitting the jaws to be moved toward one another in response to forces acting on the outer jaw surfaces and/or cams as a result of relative axial movement between the outer tubular member and the inner member. Blades **86** and **88** can be formed integrally with the jaws as a one-piece unit or formed separately of the jaws and connected thereto in any suitable manner such as, for example, by adhesive bonding, welding or mechanical attachment. Preferably, the blades are formed of a medical grade metal material such as stainless steel or titanium.

An insulated connector **98** can optionally be mounted on housing **12** opposite the handle portion or anywhere else on the instrument to connect with electrically conductive elements of the instrument for performing unipolar or bipolar electric coagulation, for example using one or both of the blades as conductive elements.

In use, instrument **10** is grasped using finger loops **40** and **44** and is guided to the operative site via a portal sleeve positioned in the wall of an anatomical cavity. The portal sleeve can be positioned in the anatomical cavity wall using any suitable penetrating technique, including those creating puncture sites by means of removable obturators such as trocars, and can include a valve housing, if desired, to prevent loss of pneumoperitoneum during insertion and withdrawal of the instrument. Visualization of the endoscopic procedure can be accomplished using a conventional endoscope incorporated into the instrument, for example within the central channel **66** defined by tubular shaft **64**, or separately positioned within the anatomical cavity through a second portal sleeve located at another puncture site.

Instrument **10** is advanced distally through the portal sleeve until jaws **18** and **20** emerge into the anatomical cavity. At this point, the instrument can be manipulated externally of the body to position the jaws at the operative site. Various grasping and cutting functions can be performed at the operative site using different portions of the jaws and by operating the handles of the instrument to open and close the jaws as required. Since inner member **16** is fixed relative to housing **12**, actuation of the jaws to open or close is controlled by moving outer tubular member **14** relative to the inner member. If closed, jaws **18** and **20** can be opened by moving outer tubular member **14** proximally relative to inner member **16**. Movement of the outer tubular member over the inner member is controlled by operation of movable handle **26**. Counterclockwise rotation of handle **26** about pin **42** results in clockwise rotation of reduction gear **62** which, in turn, causes an equal angular rotation of pinion **60**. Pinion **60** is of greater diameter than reduction gear **62** so that, for equal angles of rotation, pinion **60** will produce greater circumferential displacement. Pinion **60** engages the gear teeth of rack **58** to cause proximal movement of the outer tubular member **14** relative to jaws **18** and **20** thereby permitting the jaws to move resiliently to the open position shown in FIG. **3**. In the open position, jaws **18** and **20** are biased apart such that inner surfaces **80** and **82** of the jaws and cutting edges **90** and **92** of the blades are angularly spaced from one another allowing objects to be positioned between different portions of the jaws. Conversely, clockwise rotation of the handle **26** about pin **42** results in counterclockwise rotation of reduction gear **62** and pinion **60** causing distal movement of rack **58** and outer tubular member **14** relative to the jaws so that distal end **54** of the outer tubular member will slide over the jaws in an axial direction causing the jaws to be cammed inwardly from the open position to the closed position. As the jaws move from the open position to the closed position, inner surfaces **80** and **82** will rotate toward another to grasp objects, such as needles or tissue, disposed therebetween, and cutting edges **90** and **92** of the blades will slidingly engage one another like a scissors to cut objects, such as tissue or unsecured lengths of suture material, placed between the blades when the jaws are in the open position.

Movable handle **26** is preferably proximally spaced from fixed handle **24** as shown so that the user can maintain one or more fingers on the stationary handle **24** while operating the movable handle **26** with the thumb and/or other fingers of the hand. Movable handle **26** is preferably biased in a clockwise direction, looking at FIG. **3**, toward stationary handle **24** so that, when the movable handle is released, outer tubular member **14** will be automatically moved over jaws **18** and **20** to close the jaws together, for example to hold a suture needle between the jaws during complicated maneuvers requiring free hand movement.

In addition to performing various grasping and cutting functions, the endoscopic instrument **10** permits access to the operative site from outside the body through channel **66** formed through the instrument between proximal and distal ends of the inner tubular member. The channel can, for example, be used to introduce lengths of suture material (with or without knotting elements attached thereto) as well as any other medical devices or instruments, such as endoscopes or probes, or to perform irrigation or aspiration at the operative site, for example by attaching a source of fluid or suction to the coupling at the proximal end of the inner member, or to administer medicaments as desired.

FIGS. **6** and **7** illustrate a modification of the jaws of the endoscopic instrument according to the present invention wherein the modified upper jaw **118** carries a blade **186** with a cutting edge **190** and the modified lower jaw **120** defines a concave recess or pocket **102** for receiving the blade. Blade **186** extends perpendicularly from a proximal end of inner surface **180** of the needle holding portion of the upper jaw and is centrally located along the longitudinal axis of the inner member in opposed relation to the pocket, which is formed in the proximal end of inner surface **182** of the needle holding portion of the lower jaw. Cutting edge **190** of the blade is angularly spaced from the lower jaw when the jaws are in the open position as shown in FIG. **6**, permitting anatomical tissue and other objects to be positioned between the blade and the pocket. When jaws **118** and **120** are closed, blade **186** moves toward pocket **102** and is received therein to cut any object held between the cutting portion of the jaws. As seen in FIG. **7**, jaws **118** and **120** can be closed completely when blade **186** is disposed within pocket **102** and can thus compress or flatten the tissue or object held therebetween if desired.

The modified jaws **218** and **220** shown in FIGS. **8** and **9** are similar to the jaws described above but carry a pair of blades **286** and **288** disposed proximally of inner grasping surfaces **280** and **282** in opposed relation along lateral edges of the jaws. Blades **286** and **288** depend perpendicularly from opposed lateral edges of the jaws and have opposed cutting edges **290** and **292** spaced apart when jaws **218** and **220** are open to permit positioning of anatomical tissue and other objects between the blades. When jaws **218** and **220** are closed, cutting edges **290** and **292** of the blades move

towards one another and into sliding contact to cut any tissue or objects held between the jaws. As best seen in FIG. 9, the off-axis or eccentric position of the blades also facilitates visualization of the procedure through an endoscopic instrument positioned within channel 266.

FIGS. 10 and 11 illustrate a further modification of the endoscopic instrument wherein the upper jaw 318 carries an off-axis or eccentric blade 386 with cutting edge 390 and the lower jaw 320 defines a concave pocket 302 for receiving the blade. Blade 386 extends perpendicularly from a proximal end of inner grasping surface 380 of the needle holding portion of the upper jaw and is laterally spaced from the central longitudinal axis of the inner member to be disposed along an outer peripheral edge of the jaw in opposed relation to pocket 302. Cutting edge 390 of the blade is angularly spaced from pocket 302 in lower jaw 320 when the jaws are open permitting anatomical tissue and other objects to be positioned between the blade and the pocket. When jaws 318 and 320 are closed, blade 386 moves toward pocket 302 and is received therein to cut any tissue or object held between the jaws.

The grasping portion of the instrument jaws can be suitably configured to grasp any type of object during an endoscopic procedure. As described above, the grasping portion can be configured to include opposed surfaces which are caused to meet or come very close to one another to clamp objects such as needles positioned between the jaws by exerting a compressive force on the objects as the jaws are moved toward one another. Under certain circumstances, however, medical personnel may wish to hold an object without deforming or compressing the object, for example when moving or manipulating certain tubular organs. FIGS. 12–17 illustrate modifications of the endoscopic instrument wherein the jaws are provided with concave holding portions between which objects may be held without being deformed or compressed. In FIG. 12, the modified upper and lower jaws 418 and 420 include grasping surfaces 480 and 482 disposed distally of cutting members 486 and 488, respectively, and concave portions 404 and 406 of arcuate configuration disposed between the grasping surfaces and the cutting members and facing one another in opposed relation to define a circular or other suitably shaped opening therebetween when the jaws are closed, the opening having a size and shape to surround selected objects, such as tubular vessels and organs, without substantially traumatically compressing the objects. The modified instrument jaws 518 and 520 shown in FIG. 13 are similar to those shown in FIG. 12 but with concave portions 504 and 506 disposed proximally of grasping surfaces 580 and 582, and cutting members 586 and 588 disposed between the concave portions and the grasping surfaces. Another modification of the instrument jaws is shown in FIG. 14 wherein upper and lower jaws 618 and 620 are similar to those described above but with concave portions 604 and 606 disposed distally of cutting members 686 and 688, and grasping surfaces 680 and 682 disposed between the concave portions and the cutting members. In the modification of the instrument jaws shown in FIG. 15, upper and lower jaws 718 and 720 are similar to those described above but with grasping surfaces 780 and 782 disposed proximally of cutting members 786 and 788, and concave portions 704 and 706 disposed between the grasping surfaces and the cutting members. The modified instrument jaws 818 and 820 shown in FIG. 16 are similar to those described above but with concave portions 804 and 806 disposed distally of grasping surfaces 880 and 882, and cutting members 886 and 888 disposed between the concave portions and the grasping surfaces. Yet another modification of the instrument jaws is shown in FIG. 17 wherein upper and lower jaws 918 and 920 are similar to those described above but with concave portions 904 and 906 disposed proximally of cutting members 986 and 988, and grasping surfaces 980 and 982 disposed between the concave portions and the cutting members.

From the above, it will be appreciated that the endoscopic instrument according to the present invention permits multiple grasping and cutting functions to be performed with a single instrument while defining a channel for fluids and other medical instruments and probes to be introduced at the operative site without the need of having to remove the endoscopic needle-holding instrument from the body.

The jaws making up the jaw portion of the endoscopic instrument can be formed as an integral one-piece unit or assembled from separate pieces; and, depending on procedural use, one of the jaws can be fixed and the other movable, both jaws can be movable, the jaws can be linked by pivots or formed at the end of a tubular member or formed at the end of a pair of pivotally connected arms. The jaws, including any of the grasping or cutting portions thereof, can be straight, curved and/or angled as desired. Any of the jaws shown or described herein can be formed with opposed inner surfaces formed of repeated patterns of diamond-shaped protrusions, lateral and/or longitudinal ribs and/or other types of structural features suitable for holding needles and other types of objects during an endoscopic procedure. The jaws can have any shape in transverse cross-section when closed including, but not limited to, circular, elliptical, rectangular and polygonal configurations, and can have opposed arcuate or concave portions for holding objects, such as tubular organs, without traumatically compressing the objects. The jaws can also be of varying width in the longitudinal direction such that, for example, relatively thin cutting members or blades can be formed along a first longitudinal portion of the jaws and grasping portions of greater width than the cutting members can be formed at longitudinally spaced locations relative to the cutting members.

The cutting members or blades can be carried by one or both jaws and centrally located for cutting anatomical tissue, unsecured lengths of suture material or any other objects normally cut during a surgical procedure, or the blades can be offset laterally from the central longitudinal axis of the jaws to permit better visualization and to allow the formation of longitudinal grooves or openings through the jaws when closed. If a single blade is carried by one jaw, the other jaw can carry an opposed blade in a manner to permit sliding contact with scissor-like cutting, direct abutment of cutting edges to produce a chopping cut, and/or can form a pocket for receiving the cutting edge of the opposed blade to permit partial or complete closure of the jaws together. Furthermore, the blades can have straight, curved or angled cutting edges and can be oriented at any angle relative to a longitudinal axis of the jaws.

The handle portion of the endoscopic instrument shown and described herein is exemplary of the types of conventional handle mechanisms suitable for performing the function of actuating the jaws; accordingly, the handles can have any configuration to actuate the jaws including, but not limited to, configurations employing a pair of pivotally connected arms, one fixed and one pivoted arm, a pistol grip with a movable trigger, or resilient U-shaped handle members. Further, the handle portion of the instrument can be configured to rotate relative to a pivot axis oriented perpendicular to the longitudinal axis of the instrument so that, for example, in one position the handles will extend laterally

from the instrument or at a substantially perpendicular angle relative to the longitudinal axis; while, in another position, the handles will extend proximally from the instrument like scissor handles.

It will be appreciated that the handle portion and jaw portion of the endoscopic instrument can be integrally formed as a one-piece unit or formed as separate components and coupled together, for example, by use of pivots, linkages, rods, cables, telescoping members, brackets and other mechanical and/or electrical couplings.

When the instrument is formed of telescoping members, it will also be appreciated that individual tubular members, such as the inner member can be made rotatable about a longitudinal axis of the instrument either alone or in combination with other telescoping members. Moreover, when the instrument is coupled with a source of fluid or suction, an operating unit or other medical device, the instrument housing can have any configuration for being releasably coupled including, but not limited to threaded or telescoping portions, detents, latches or any other suitable connections. Furthermore, the housing can be cylindrical or rectangular or have any other useful or convenient configuration in cross-section.

The inner member can define one channel as shown or multiple channels of similar or different cross-sectional configuration. Any of the channels defined by the inner member can be coaxially disposed or offset from the central longitudinal axis of the inner member and can have any suitable configuration in cross-section dependent upon procedural use including, but not limited to, circular, elliptical and polygonal cross-sectional configurations.

The outer tubular member can have any suitable configuration in cross-section to fit through a portal formed in the wall of an anatomical cavity and to receive the inner member for sliding movement therein. The distal end of the outer tubular member can be blunt, tapered, beveled or chamfered, and can also be provided with longitudinal slots or interior grooves for receiving protrusions or cams carried on the outer surfaces of the jaws to assist in maintaining proper alignment of the jaw blades when cutting tough materials. Alternatively, protrusions can be carried on an interior surface of the outer tubular member in alignment with slots or grooves formed in the jaws to maintain alignment during operational use.

The components of the endoscopic instrument of the present invention can be made of any suitable, medical grade materials to permit sterilization for reuse or disposal for single patient use. The components can be made of multiple parts of various configurations and materials to reduce cost and/or simplify fabrication. The instrument can have various valves, stop cocks and seals in the housing and/or inner member to control fluid flow therethrough.

The features of the various embodiments described above can be combined in any manner desired dependent upon the operational requirements of the procedure to be performed and the complexity of the endoscopic instrument.

Inasmuch as the present invention is subject to many variations, modifications and changes to detail it is intended that all subject matter discussed above or shown in the accompanying drawings be interpreted as illustrative only and not be taken in a limiting sense.

What is claimed is:

1. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity comprising

a handle; and

an elongate tubular member having a proximal end coupled with said handle for being disposed externally of the anatomical cavity and a distal end for being disposed within the anatomical cavity and carrying a pair of opposed, relatively movable jaws;

said jaws defining a grasping portion operable by manipulation of said handle to grasp objects and a cutting portion operable by manipulation of said handle to cut tissue.

2. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said tissue cutting portion includes a blade.

3. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said tissue cutting portion includes a pair of blades carried by said jaws in opposed relation.

4. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said tissue cutting portion includes a blade carried by a first of said jaws and a recess formed in a second of said jaws in opposed relation to said blade to receive said blade when said jaws are moved toward one another.

5. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 2 wherein said blade is oriented parallel to a longitudinal axis of said elongate tubular member.

6. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 5 wherein said blade is disposed along a central longitudinal axis of said elongate tubular member.

7. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 5 wherein said blade is laterally offset from a central longitudinal axis of said elongate tubular member.

8. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said grasping portion is longitudinally spaced from said tissue cutting portion to hold a needle.

9. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said jaws include opposed concave portions longitudinally spaced from said tissue cutting portion for defining an opening between said jaws to hold an object during an endoscopic procedure without compressing the object.

10. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said grasping portion is disposed distally of said cutting portion and wherein at least one of said jaws includes a concave portion between said grasping portion and said tissue cutting portion to hold an object during an endoscopic procedure without compressing the object.

11. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein at least one of said jaws includes a concave portion distally spaced from said tissue cutting portion to hold an object during an endoscopic procedure without compressing the object and wherein said grasping portion is disposed between said concave portion and said tissue cutting portion.

12. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said grasping portion is disposed distally of said tissue cutting portion and at least one of said jaws includes a concave portion proximally spaced from said tissue cutting portion to hold an object during an endoscopic procedure without compressing the object.

13. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said grasping portion is proximally spaced from said tissue cutting portion and at least one of said jaws includes a concave portion distally spaced from said tissue cutting member to hold an object during an endoscopic procedure without compressing the object.

14. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said grasping portion is proximally spaced from said tissue cutting portion and at least one of said jaws includes a concave portion disposed between said grasping portion and said tissue cutting portion to hold an object during an endoscopic procedure without compressing the object.

15. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein at least one of said jaws includes a concave portion proximally spaced from said tissue cutting portion to hold an object during an endoscopic procedure without compressing the object and wherein said grasping portion is disposed between said concave portion and said tissue cutting portion.

16. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said proximal and distal ends of said elongate tubular member are open and further comprising a valve disposed between said proximal and distal ends.

17. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 and further comprising a coupling carried at said proximal end of said elongate tubular member for connection with other medical instruments.

18. A multifunctional endoscopic instrument for use in performing endoscopic procedures within an anatomical cavity as recited in claim 1 wherein said jaws are biased apart toward an open position and further comprising an outer tubular member disposed telescopically around said elongate tubular member and having a proximal end coupled with said handle and a distal end movable relative to said elongate tubular member by manipulation of said handle between a retracted position allowing said jaws to open and an extended position causing said jaws to close.

* * * * *

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(54) SURGICAL CLAMP PAD WITH INTERDIGITATIN TEETH

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(22) Filed: Apr. 25, 2002

Related U.S. Application Data

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Publication Classification

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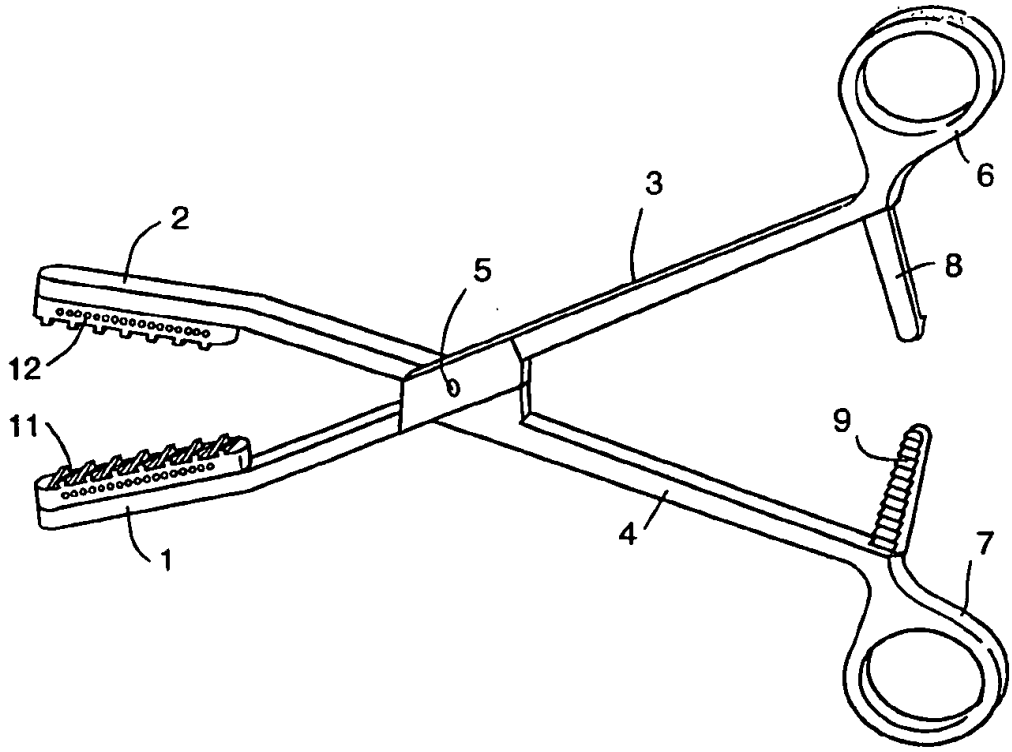
(52) U.S. Cl. 606/207

(57) ABSTRACT

Opposable surgical clamp members having opposable resilient pads with wedge-shaped and cylindrical protrusions extending from the surfaces of the pads and the use of such members for occluding vessels and other tubular body structures are described. The protrusions are arranged such that when the members are moved toward one another, the protrusions of one pad interdigitate with the protrusions of the other pad. Upon engagement with a vessel, portions of the vessel are forced into the interdigital spaces providing for improved gripping of the vessel. The protrusions also resist lateral or transverse movement of a clamped vessel relative to the pads. The existence of through holes under the pad surface alters the relative resiliency of the pad, allowing for an overall pad resiliency that minimizes trauma to a clamped vessel while allowing the local resiliency of the protrusions themselves to be of a hardness to avoid excessive deflection and retain the desired shape and gripping ability.



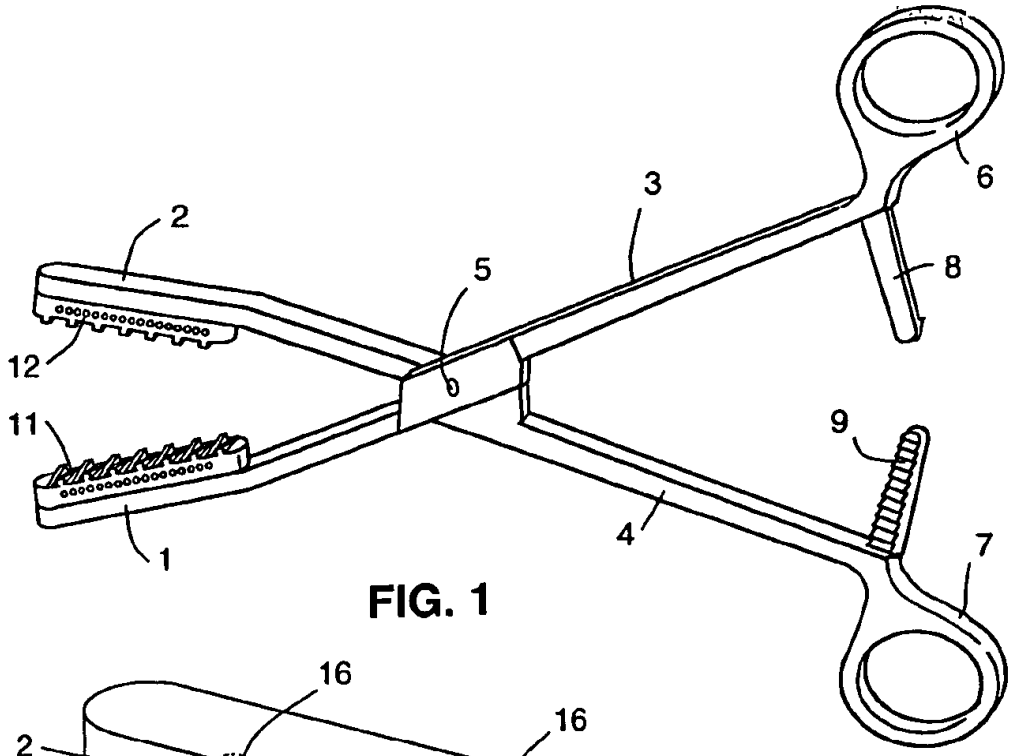


FIG. 1

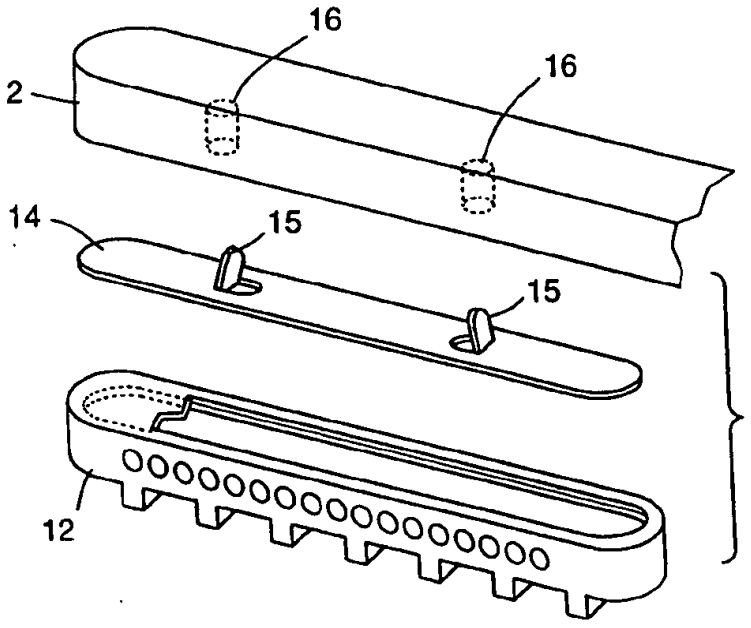


FIG. 2

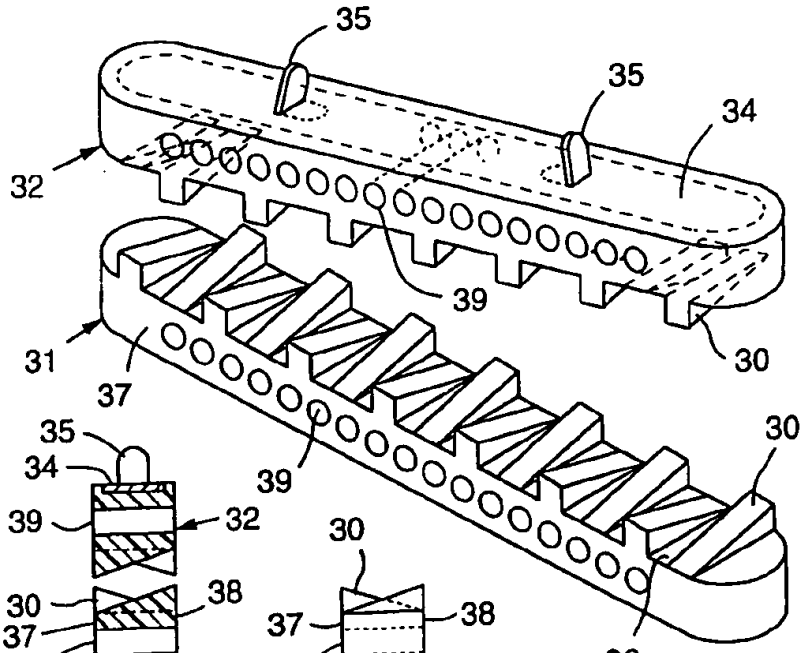


FIG. 3

FIG. 7

FIG. 5

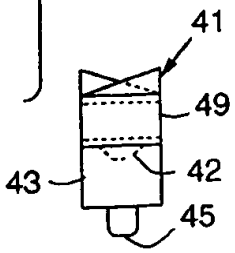


FIG. 9

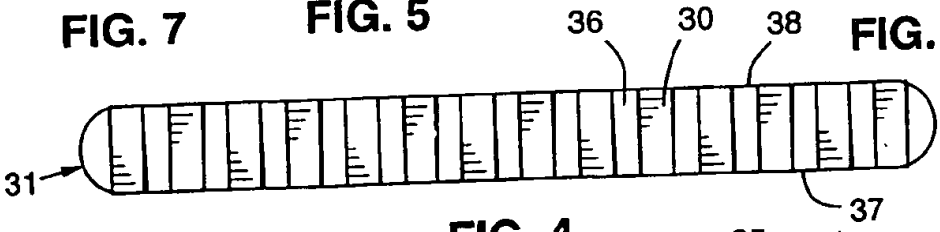


FIG. 4

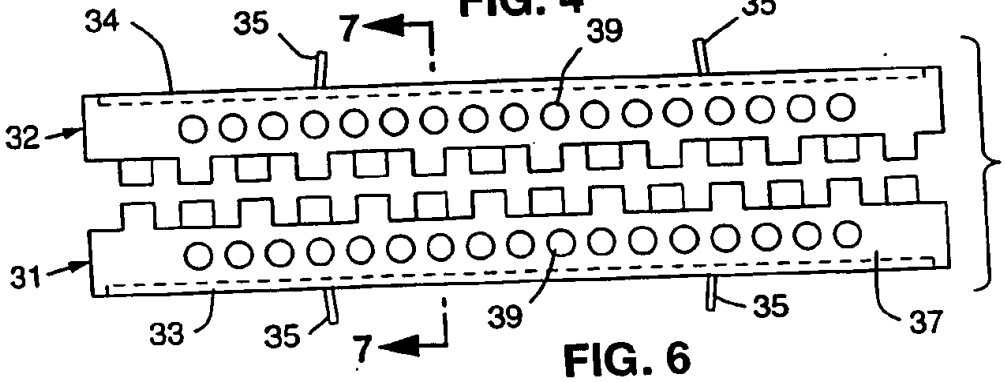


FIG. 6

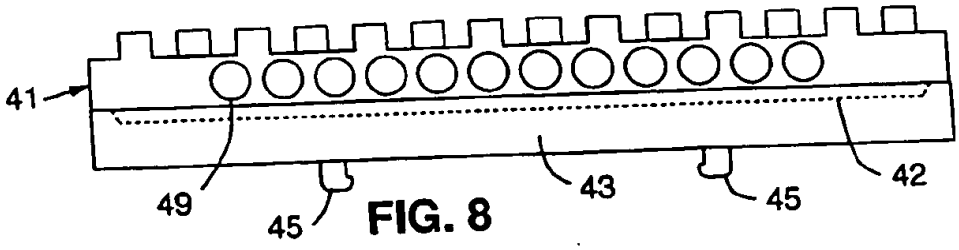


FIG. 8

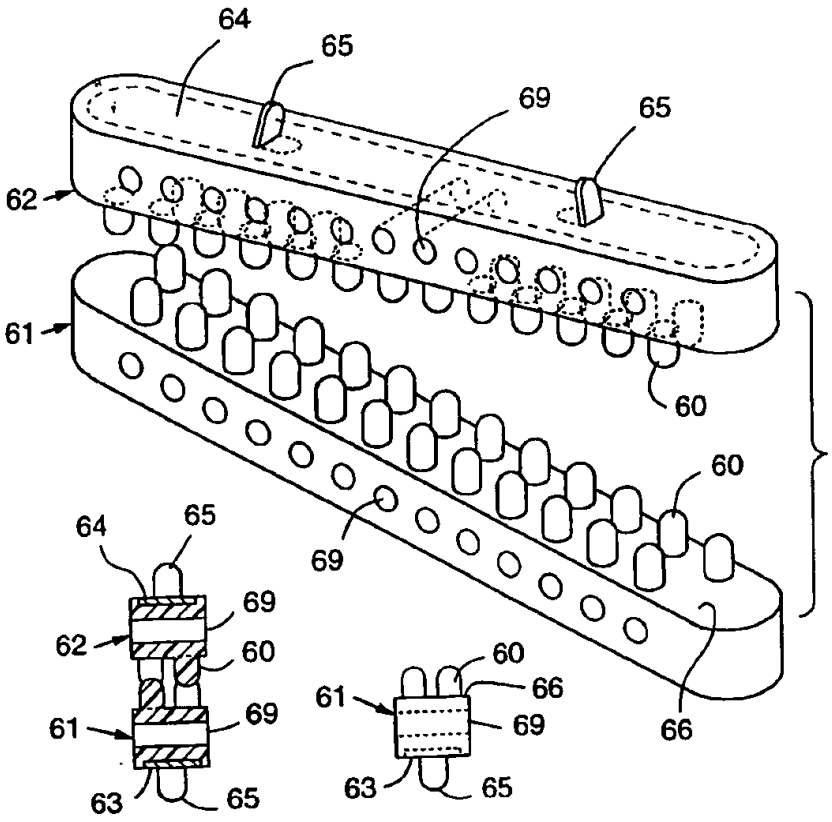


FIG. 10

FIG. 14

FIG. 12

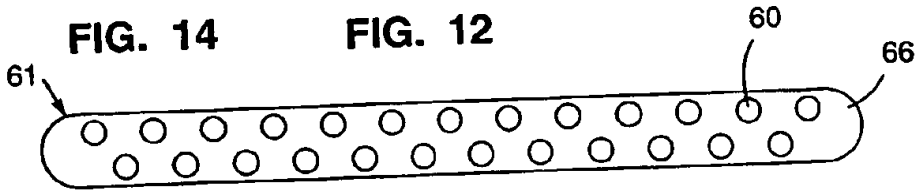


FIG. 11

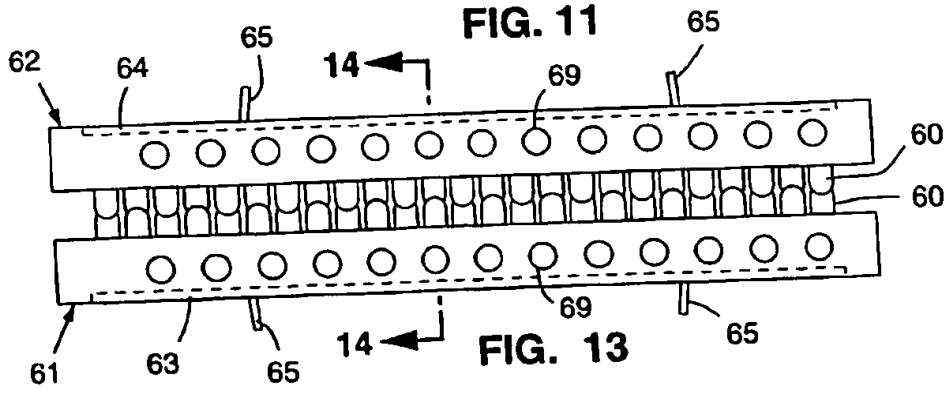


FIG. 13

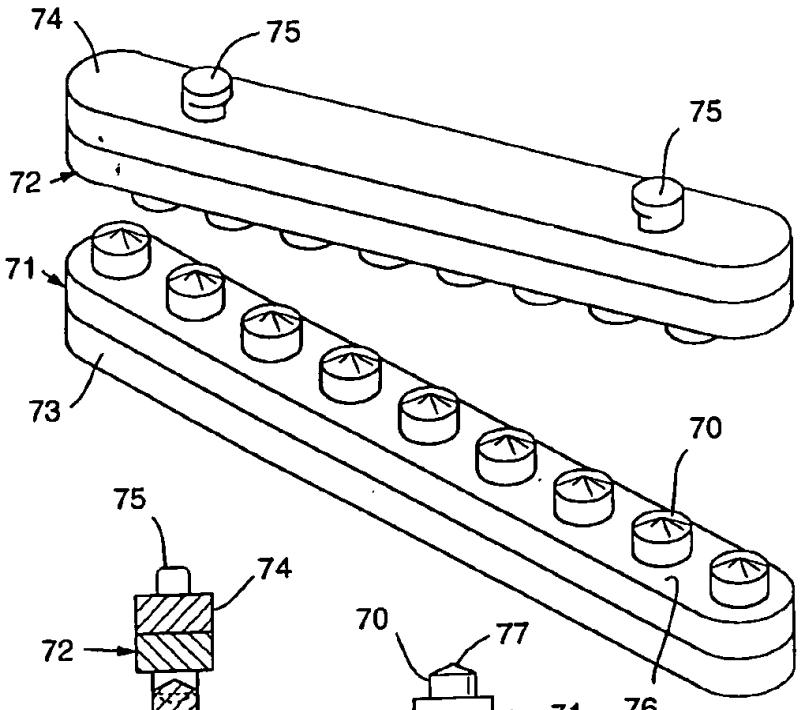
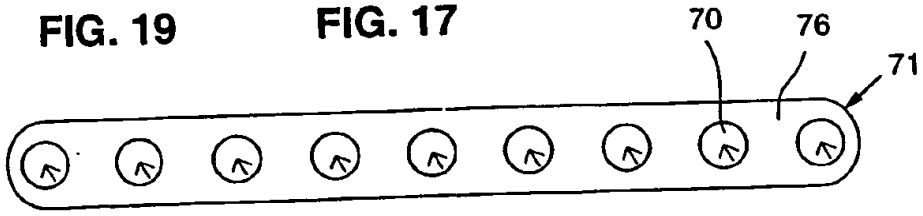


FIG. 15

FIG. 19

FIG. 17



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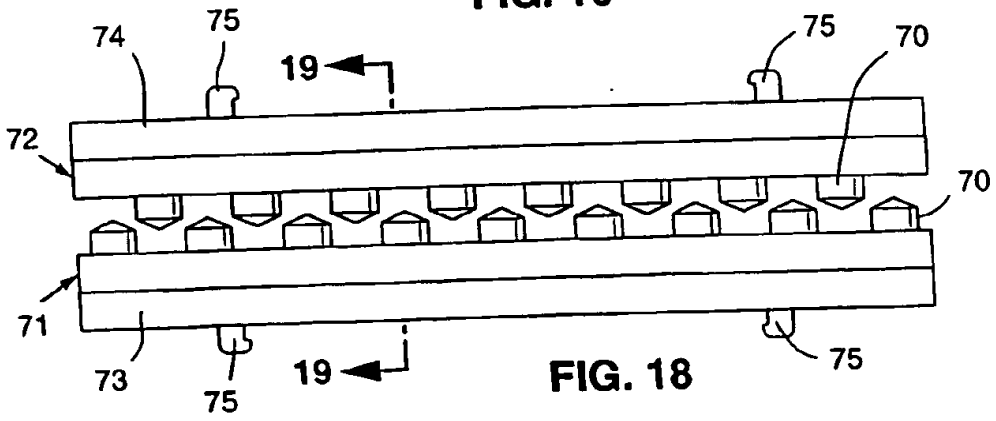

FIG. 18

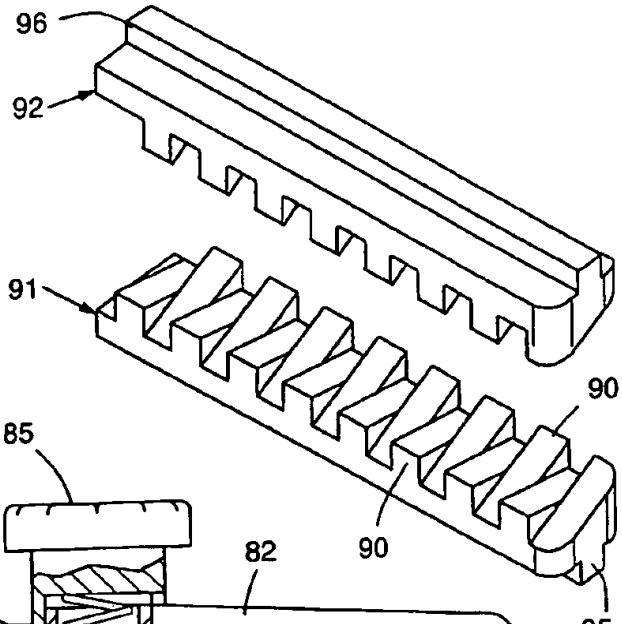

FIG. 21

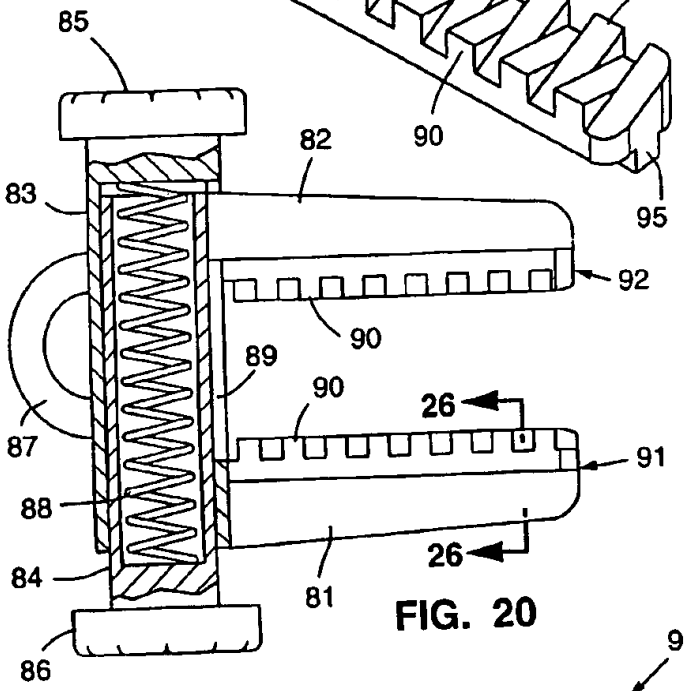

FIG. 20

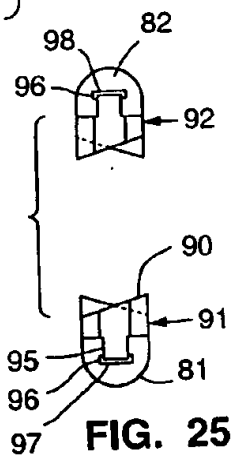

FIG. 25

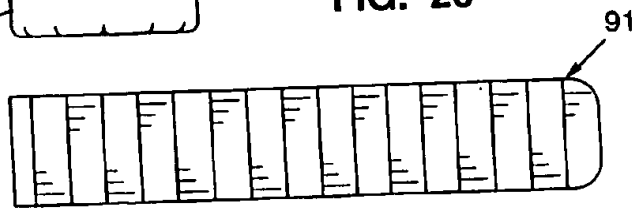

FIG. 22

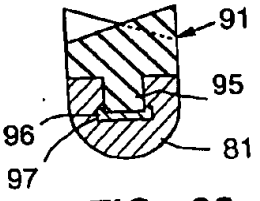

FIG. 26

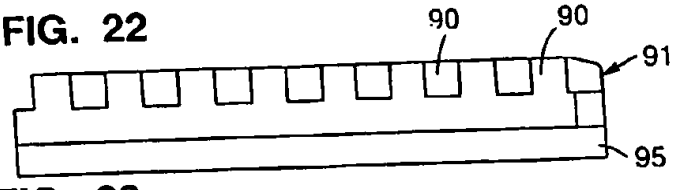

FIG. 23

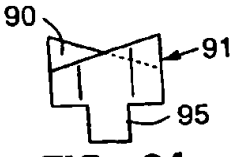

FIG. 24

SURGICAL CLAMP PAD WITH INTERDIGITATIN TEETH

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates generally to clamping members for attachment to a jaw-type surgical clamping device for atraumatically occluding a vessel or other tubular structure. More particularly, the invention relates to clamping members that include opposable resilient pads having surface protrusions where the protrusions of the opposing pads interdigitate to provide improved gripping of the occluded vessel or tubular structure.

[0003] 2. Description of the Related Art

[0004] Instruments for occluding blood vessels or other tubular structures of a patient's body during surgery, such as conventional metal or rigid surgical clamps or clips, are well known. Such instruments, however, are known to cause trauma to the clamped vessel at the clamping site. A number of atraumatic instruments have been developed for reducing or eliminating the trauma to a vessel during occlusion of the vessel. U.S. Pat. No. 3,993,076 to Fogarty, et al. discloses a device whereby a vessel is occluded by using a resilient tape to press a vessel against a resilient pad. However, this device suffers from the disadvantage that it slips easily. For example, the pulsations of an occluded artery can tend to force the device off of its clamped position on the occluded artery. Conventional surgical clamps have also been adapted to include jaw surfaces containing resilient members or pads. These devices likewise are prone to slipping off of the clamped vessel. This can be especially problematic in situations where, due to obstructions, a vessel has been clamped with only the distal tips of the clamp jaws. In such situations, the vessel can be especially prone to slipping in the direction of the distal tips.

[0005] Other attempts have been made to atraumatically occlude a vessel in a more secure fashion. U.S. Pat. No. 3,746,002 to Haller discloses a vascular clamp with resilient gripping members located on the jaws. A plurality of pin members are embedded within the gripping members, the pin members being of a length such that when a vessel is clamped between the members, the resilient material deflects to accommodate the vessel, exposing the pin members which grippingly engage the outer layer of the vessel, thus securing the vessel to the gripping member. While the Haller device is less traumatic to a vessel than other occlusion devices, it nevertheless has the disadvantage of traumatizing the outer layer of the vessel.

[0006] U.S. Pat. No. 4,821,719 to Fogarty discloses a vascular clamp device containing resilient pads with Velcro-like hooks. The hooks interact with the external adventitial layer of the vessel forming a cohesive-adhesive relationship with the vessel similar to the bonding of Velcro materials. While this device offers a less traumatic way to occlude a vessel, the cohesive-adhesive nature of the bond can result in the removal of some of the adventitial layer of the vessel when disengaging the device.

[0007] U.S. Pat. No. 3,515,139 to Mallina discloses surgical forceps with hard plastic inserts having spherical protuberances and complementary grooves or spherical cavities. U.S. Pat. No. 3,503,397 to Fogarty discloses surgical clamps with jaw inserts having hard plastic teeth along the edges of the insert with a softer component along the interior of the insert. The hard teeth of this device serve to resist movement of a clamped vessel laterally of the jaw, but do so at increased risk of trauma to the vessel.

[0008] There is thus a need for a surgical clamp which atraumatically occludes vessels with improved gripping capabilities while simultaneously avoiding the disadvantages previously associated with existing surgical clamps or occlusion devices.

SUMMARY OF THE INVENTION

[0009] The present invention provides for opposing surgical clamp members having opposing resilient pads with clamping surfaces that have interdigitating protrusions or "teeth" that extend from the surfaces of the pads for engagement with a vessel. As used herein, the general term "vessel" shall refer to a blood vessel or other tubular body structure. The protrusions are arranged in rows lengthwise along pairs of opposable pads such that when the pads are brought together, the protrusions of one pad interdigitate with the protrusions of the other pad. When engaged with a vessel, portions of the vessel, including the adventitial layer, will be forced into the interdigital spaces between the protrusions, providing for improved gripping of the vessel or tissue. At the same time, the resiliency of the protrusions ensures against trauma to the clamped vessel or tissue.

[0010] The protrusions themselves can be of varying shapes, including cylindrical-shaped protrusions or wedge-shaped protrusions. Where cylindrical protrusions are used, the protrusions can culminate in varying tip shapes, for example, blunt cut, hemispherical or conical tips can be used. The protrusions can also include discrete gripping edges to further increase the traction on an engaged vessel. In every case, the resiliency of the protrusions is such that the protrusions will deflect upon engagement with a vessel but will not distort too greatly from their overall original shape. It is important that the resiliency of the pad as a whole is adequate to impart a cushioning effect upon the clamped vessel, while at the same time the protrusions of the pad retain enough of their original shape to effectively interdigitate with the protrusions of the opposing pad when the pads are brought together in engagement with the vessel. In this manner, the engaged vessel is effectively gripped while minimizing trauma or damage to the vessel. Optimally, the pad itself is of a single-piece construction with the protrusions integrally formed with the remainder of the pad.

[0011] In an embodiment of the invention, the relative resiliency of the pad can be altered by including a series of through holes located below the pad surface and transverse to the length of the pad. The holes can be of varying diameter and varying spacing. One skilled in the art will realize that multiple arrangements of through holes can be used, provided that the result is that the underlying portion of the pad containing the through holes is more easily deflected than the protrusions of the overlying surface portion of the pad. The pad thus provides a greater overall cushioning effect for a clamped vessel while at the same time providing the gripping protrusions with a sufficient hardness to resist excessive deformation upon engagement with a clamped vessel. The through holes can extend along the entire length of the pad or, alternatively, extend only

along the portions of pad length, for example, along the center portion of the pad. In this latter configuration, the pad will be more easily deflected along the center portion and stiffer towards the ends of the pad. Vessels clamped in the center of the pads will be restrained from slipping toward the ends of the pads because movement of the vessel in those directions will be resisted in part due to the stiffer resilience of the end portions of the pads.

[0012] In further embodiments of the invention, the protrusions can be oriented to further resist movement of clamped vessel in particular directions relative to the pads. In one embodiment, the protrusions can be formed in the shape of wedges oriented perpendicular to the length of the pad with the raised ends of the wedges flush with the sides of the pad. In this configuration, movement of a clamped vessel in a direction transverse to the pad will be restricted by the raised ends of the wedges. By arranging the wedges in alternating fashion along the pad length, lateral or transverse movement of a clamped vessel relative to the pad is restricted. In other embodiments, the protrusions can be cylindrical and extend upward from the pad surface. In such configurations, lateral or transverse movement of the clamped vessel relative to the pad will be restricted in like fashion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a perspective view of a surgical clamp with attached clamping member according to the present invention;

[0014] **FIG. 2** is an exploded perspective view of the surgical clamp of **FIG. 1** with part of the clamp broken away;

[0015] **FIG. 3** is a perspective view of opposing surgical clamping members capable of attachment to the jaws of a surgical clamp, with opposing surfaces having protrusions according to a first embodiment of the present invention;

[0016] **FIG. 4** is a plan view of one of the clamping members of **FIG. 3**;

[0017] **FIG. 5** is an end view of the clamping member of **FIG. 4**;

[0018] **FIG. 6** is a side view of the clamping members of **FIG. 3** with the opposing surfaces of the members aligned with each other;

[0019] **FIG. 7** is a cross-sectional view of the members of **FIG. 6** taken on the plane designated by line **7-7** of **FIG. 6**;

[0020] **FIG. 8** is a side view of a clamping member similar to the clamping members of **FIG. 6**;

[0021] **FIG. 9** is an end view of the clamping member of **FIG. 8**;

[0022] **FIG. 10** is a perspective view of opposing surgical clamping members according to a second embodiment of the present invention with opposing surfaces having a different arrangement of protrusions;

[0023] **FIG. 11** is a plan view of one of the clamping members of **FIG. 10**;

[0024] **FIG. 12** is an end view of the clamping member of **FIG. 11**;

[0025] **FIG. 13** is a side view of the clamping members of **FIG. 10** with the opposing surfaces of the members aligned with each other;

[0026] **FIG. 14** is a cross-sectional view of the members of **FIG. 13** taken on the plane designated by line **14-14** of **FIG. 13**;

[0027] **FIG. 15** is a perspective view of opposing surgical clamping members according to a third embodiment of the present invention with opposing surfaces having another arrangement of protrusions;

[0028] **FIG. 16** is a plan view of one of the clamping members of **FIG.15**;

[0029] **FIG. 17** is an end view of the clamping member of **FIG. 16**;

[0030] **FIG. 18** is a side view of the clamping members of **FIG. 15** with the opposing surfaces of the members aligned with each other;

[0031] **FIG. 19** is a cross-sectional view of the members of **FIG. 18** taken on the plane designated by line **19-19** of **FIG. 18**;

[0032] **FIG. 20** is a side view of a surgical clip with attached clamping members according to a fourth embodiment of the present invention;

[0033] **FIG. 21** is a perspective view of opposing surgical clamping members according to the fourth embodiment of the present invention, illustrating the arrangement of the protrusions on the opposing surfaces and that the clamping members are capable of attachment to the jaws of a surgical clip;

[0034] **FIG. 22** is a plan view of one of the clamping members of **FIG. 21**;

[0035] **FIG. 23** is a side view of the clamping member of **FIG. 22**;

[0036] **FIG. 24** is an end view of the clamping member of **FIG. 23**;

[0037] **FIG. 25** is an end view of the jaws of the spring clip depicted in **FIG. 20** with attached clamping members according to the present invention; and

[0038] **FIG. 26** is a cross-sectional view of the jaw-clamping member assembly of **FIG. 20** taken on the plane designated by line **26-26** of **FIG. 20**.

DETAILED DESCRIPTION OF THE INVENTION

[0039] **FIG. 1** illustrates a surgical clamp comprising a pair of opposed jaws **1** and **2** and handles **3** and **4** hinged together by pin **5**. The handles **3** and **4** terminate in finger and thumb rings **6** and **7** which provide for manual operation of the jaws by a surgeon. Interlocking pawl **8** and ratchet teeth **9** are provided on handles **3** and **4**, respectively, to secure jaws **1** and **2** in an adjusted clamped position. The opposed jaws **1** and **2** include clamping members according to the present invention comprising opposed pads **11** and **12**. The pads themselves are secured to base members **14** that are in turn detachably secured to opposed jaws **1** and **2**. As depicted in **FIG. 2**, base member **14** provides a rigid backing for pad **12** as well as means for attachment of pad **12** to

opposed jaw **2**. Base members can be made of metal, such as stainless steel, or of a hard plastic, such as polycarbonate. As shown in **FIG. 2**, a means for attaching pad **12** to opposed jaw **2** can comprise a pair of tabs **15, 15** on base member **14** that can be detachably secured to corresponding recesses **16, 16** on jaw **2**.

[0040] The pads are comprised of a resilient material having raised protrusions extending from the surfaces of the pads, and it is preferred that the pads are of a single piece construction where the protrusions are integrally formed with the remainder of the pad. The resilient material can have a resilience ranging from about 30 to about 60 durometer. A variety of resilient materials are useful for forming the pads, including natural rubber, neoprene, urethane, ethyl vinyl acetate foam or silicone foam. The preferred resilient material is silicone rubber or silicone. The preferred method of making the pads is to liquid injection mold the pads using silicone, according to ways known in the art.

[0041] The invention contemplates various sizes, shapes and arrangements of protrusions, as exemplified by the various embodiments. In all cases the protrusions are of a size, shape and arrangement so that the protrusions of opposing pads interdigitate with one another when the opposing pads are moved toward one another. By interdigitate it is meant that the protrusions of one pad extend into spaces between counterpart protrusions of the other pad when the pads are moved towards one another. Once brought together, remaining or interdigital spaces will exist between the now interdigitated protrusions of the pads. Vessels engaged between the pads, including the advential layer of such vessels, will be forced under clamping pressure to wind around the protrusions and into the interdigital spaces. The displacement of the clamped vessel into the interdigital spaces increases the traction and gripping force of the pads upon the engaged vessel or tissue and increases the force required to move the gripped vessel or tissue relative to the pads. In addition, protrusions having gripping edges provide additional traction and further resist movement of the gripped vessel in directions transverse to the gripping edges.

[0042] One skilled in the art will recognize that a number of different shapes, sizes and arrangements of interdigitating protrusions can be used in the present invention and the invention is not intended to be limited to the specific embodiments that follow.

FIRST EMBODIMENT

[0043] A first embodiment of a clamping member according to the present invention is depicted in FIGS. **3-9**. Resilient pads **31** and **32** are attached to base members **33** and **34**, respectively. Pads **31** and **32** are comprised of silicone and formed around base members **33** and **34** by a conventional liquid injection-molding process well known in the art. Once the pads cure or harden, the base members are permanently secured to the pads. Base members **33** and **34** are formed of stainless steel and include spaced apart tabs **35, 35** that can be detachably secured within corresponding recesses in the jaw of a surgical clamp. The tabs are slightly angled toward each other and the respective recesses are undercut so that once the tabs are placed within the recesses, the ends of the tabs snap beneath the undercut, releasably securing the pad to the jaw.

[0044] Protrusions in the general shape of wedges **30** extend from planar surface **36** of each pad **31, 32**. The wedges are arranged in rows along the length of each pad and each wedge is oriented transverse to the length of the pad. The wedges of the first row are staggered relative to the wedges **30** of the second row, that is, the wedges of the first row and second row alternate, as shown in **FIG. 3**. In the preferred embodiment, the upright ends of the wedges of the first row are formed flush with the side **37** of the pad **31**, and the inclined surfaces of the wedges slope downward and terminate at the side **38**, along the same line of intersection as the planar surface **36** and side **38**. The wedges of the second row are arranged conversely, with the ends flush with side **38** and the inclined surfaces sloping downward to terminate along the line of intersection between planar surface **36** and side **37**.

[0045] In operation, when the two pads are brought together, the wedges of one pad interdigitate with the wedges of the other pad and the inclined surfaces of the wedges of one pad mate with the inclined surfaces of the corresponding wedges of the opposed pad, as depicted in FIGS. **6-7**. The gripping edges of the wedges provide for improved traction in gripping a clamped vessel. The sides of the wedges resist relative movement of the clamped vessel engaged between the two pads along a direction parallel to the length of the pad. The raised ends of the wedges resist relative movement of the clamped vessel in a direction transverse to the length of the pad. By alternating the orientation of the wedges along the pad, lateral movement can be restricted in either direction transverse to the length of the pad.

[0046] The wedges can have a height to width to length ratio ranging from about 1:1:2.5 to about 1:1:4 with the length of the wedge being generally equal to the overall pad width. Wedges of these dimensions that have the appropriate resiliency will retain their shape upon engagement with a vessel. Wedges that are too thin relative to their height will have a tendency to bend over upon themselves upon engagement with a vessel. In such a case, the gripping edges of such wedges will not contact the vessel and the effective interdigitation of opposing wedges will be thwarted.

[0047] Most vessels subject to clamping by the pads of the present invention will have diameters ranging from 0.10 to 3.0 inches, with the diameter of the average vessel being about 0.25 inches. For best gripping, it is desirable that several wedges of a pad are in contact with a clamped vessel at any one time. Preferably, the wedges have a width of approximately 0.030 to 0.080 inches, a height of approximately 0.024 to 0.080 inches, and a length equivalent to the pad width, that is, about 0.125 inches. In the preferred embodiment, the wedges are 0.040 inches high, 0.040 inches wide and 0.125 inches in length. Gaps between the wedges are also provided for in this embodiment of the invention, as depicted in FIGS. **3-7**. The preferred gap width is 0 to 0.16 inches, and is most preferably 0.040 inches. A vessel clamped between pads of this configuration will have portions of the vessel engaged between the inclined surface of opposing reciprocal wedges alternating with portions engaged in the gap areas between the wedges. The result is alternating areas of high compression and low compression along the clamped vessel. The transition areas between the areas of high and low compression provide for an additional source of traction for gripping the vessel.

[0048] As shown in FIGS. **3-7**, the relative resiliency of pads **31, 32** are adjusted by the inclusion of a series of

through holes **39** passing through each pad below each pad surface. The holes can occur along the entire length of the pad or along a discrete portion of the pad. The holes can be uniform or varying in diameter, and can be equally or variably spaced along the pad length. Preferably, the holes are uniform in diameter, uniformly spaced, and are oriented with the axis of each hole transverse to the pad length. In the most preferred embodiment, the holes are 0.040 inches in diameter, are spaced 0.060 inches apart as measured from the centers of each hole. The holes run along the entire length of the pad, with the exception of the terminal end portions of the pad, corresponding to about 5-10% of the total pad length, as shown in **FIG. 6**. In the preferred embodiment, the pad itself is formed of a 50 durometer silicone (GE 6050) but the inclusion of the through holes yields a pad with an effective resilience of 35 durometer, as measured by an "A" scale durometer tester (VWR Scientific, Westchester, Pa.). The provision of the through holes in the pad reduces the overall relative resiliency of the pad thereby providing for a greater cushioning effect on a clamped vessel. At the same time this overall reduction in resiliency allows for the wedges **30** themselves to have a stiffer resiliency so they can better retain their general shape and gripping edges upon engagement with a clamped vessel and more effectively interdigitate with wedges of opposing pads, providing for improved gripping of the clamped vessel.

[0049] FIGS. **8-9** depict a variation of the first embodiment with a pad configuration similar to that shown in FIGS. **3-6**. In this variation the pad **41** has through holes **49** of a larger diameter than those depicted in FIGS. **3-7**. The through holes are approximately 0.060 inches in diameter and are spaced apart at a distance of approximately 0.080 inches, relative to the centers of each hole. As depicted in FIGS. **8-9**, the through holes span only the center portion of pad **41**, corresponding to about 70% of the total pad length. With this configuration of through holes, the pad has a softer overall resiliency along the center portion of the pad than at either end of the pad. A pad of this configuration comprised of 50 durometer silicone will have an effective resiliency of approximately 30 durometer along the center portion of the pad containing the through holes, while the resiliency of the pad at either end will remain at approximately 50 durometer. The relative hardness of the ends of the pads as compared to the center portion helps to resist movement of a vessel clamped in the center of the pads toward either ends of the pads.

[0050] In addition, pad **41** includes ridge **42** running lengthwise along the bottom surface of the pad. Base member **43** contains a corresponding depression to receive ridge **42**, and the pad is secured to the base member, preferably with an adhesive. The base member itself is formed of a hard plastic, such as polycarbonate. The base member also includes spaced apart knobs **45** that are received into reciprocal recesses in a jaw member of a surgical clamp to releasably secure the clamping member to the jaw member. The recesses are undercut and the heads of the knobs have slight protrusions directed toward one another that snap into the undercut of the recesses to secure the pad to the jaw member.

SECOND EMBODIMENT

[0051] A second embodiment of a clamping member according to the present invention is depicted in FIGS. **10-14**. Resilient pads **61** and **62** are attached to base members **63** and **64**, respectively. Preferably, the pads **61** and **62** are of 50 durometer silicone (GE 6050) and are formed around base members **63** and **64** in similar fashion as described above for the first embodiment. Again, base members **63** and **64** are formed of stainless steel, and include tabs **65, 65** that can be detachably coupled to corresponding recesses in the jaw of a surgical clamp. Cylindrical protrusions **60** extend from planar surface **66** of each pad **61, 62**. The protrusions **60** are arranged in two rows along the length of each pad **61, 62** with the protrusions of the first row staggered relative to the protrusions of the second row, as depicted in **FIG. 11**. As shown in **FIG. 12**, the cylindrical protrusions **60** extend from the pad surface **66** perpendicular to the pad surface and can terminate in hemi-spherical tips. The protrusions have a height to width ratio ranging from about 0.8:1 to about 1:1. In the preferred embodiment, the protrusions are 0.040 inches high, 0.040 inches wide, and are spaced at intervals of approximately 0.100 inches within each row. The distance between the two rows is approximately 0.060 inches.

[0052] In operation, when the two pads are brought together, the protrusions of one pad interdigitate with the protrusions of the opposing pad. The side walls of the protrusions, oriented in at right angles to the pad surface, present barriers to the movement of a clamped vessel engaged between the two pads in any direction parallel to the plane of the pad surface, including directions both parallel and transverse to the pad length.

[0053] In this embodiment, as in the first embodiment, the relative resiliency of the pad can be adjusted by providing a series of through holes **69** passing through each pad below each pad surface. Again, the holes can occur along the entire length of the pad or along a discrete portion of the pad. The holes can be of uniform or varying diameter, and can be uniformly or variably spaced along the pad length. Preferably, the holes **69** are uniform in diameter, run the length of the pad, and are oriented with the axis of each hole transverse to the pad length, as depicted in FIGS. **13-14**. In the preferred embodiment, the holes are 0.040 inches in diameter and are spaced 0.060 inches apart, relative to the centers of each hole. Again, the provision of the through holes in the pad reduces the overall relative resiliency of the pad thereby providing for a greater cushioning effect on a clamped vessel. At the same time this overall reduction in resiliency allows for the protrusions **60** themselves to have a stiffer resiliency so they can better retain their general shape upon engagement with a clamped vessel and more effectively interdigitate with protrusions of the opposing pad, thereby providing for improved gripping of the clamped vessel. In this embodiment, as in the first embodiment, while the pad is comprised of a 50 durometer silicone, the provision of the through holes provides for an effective pad resiliency of approximately 35 durometer.

THIRD EMBODIMENT

[0054] A third embodiment of a clamping member according to the present invention is depicted in FIGS. **15-19**. Resilient pads **71** and **72** are formed of 40 durometer silicone (GE 6040) and attached to base members **73** and **74**, respectively, preferably by the use of an adhesive. The base members **73** and **74** are formed of a hard plastic, such as polycarbonate, and include knobs **75, 75** that can be detach-

ably coupled to corresponding recesses in the jaw of a surgical clamp, as described above with respect to the **FIG. 8** and **9** variation of the first embodiment. Cylindrical protrusions **70** extend from planar surface **76** of each pad **71** and **72**, and are arranged in a single row along the length of each pad, as depicted in FIGS. **15-18**. As shown in **FIG. 17**, the cylindrical protrusions **70** extend from the pad surface **76** in a direction perpendicular to the pad surface. The cylindrical protrusions **70** themselves terminate in conical tips **77**. In alternative embodiments, the protrusions can terminate in rounded or flat tips. The protrusions have a height to width ratio ranging from 1:1 to about 1:2. In the preferred embodiment, the cylindrical protrusions have a height of 0.040 inches to the base of the conical tip, with the conical tip extending another 0.010 inches. The protrusions are approximately 0.063 inches wide and are spaced at intervals of approximately 0.100 inches.

[0055] In operation, when the two pads are brought together, the protrusions of one pad interdigitate with the protrusions of the opposing pad. The side walls of the protrusions, oriented at right angles to the pad surface, present barriers to the movement of a clamped vessel engaged between the two pads in any direction parallel to the plane of the pad surface, including directions both parallel and transverse to the pad length.

FOURTH EMBODIMENT

[0056] A fourth embodiment of the clamping member according to the present invention is depicted in FIGS. **20-26**. This embodiment is designed to attach to surgical spring clips of the type depicted in **FIG. 20**. The surgical clip shown in **FIG. 20** comprises a pair of opposing jaws **81** and **82** that are attached to cylinders **83** and **84**, respectively. Each cylinder has an open end, a closed end, and an interior chamber. Cylinder **84** is of a smaller diameter than cylinder **83** and nests inside cylinder **83**. Eyelet **87** extends outward from cylinder **83**. Jaw **82** is attached to the outer wall of cylinder **84** at the open end of cylinder **84** and jaw **81** is likewise attached to the outer wall of cylinder **83** at the open end of cylinder **83**. Spring **88** extends lengthwise within the interior chambers of the cylinders, with the ends of the spring in engagement with the closed ends of the cylinders. The spring pushes against the closed end of each cylinder to force the cylinders apart, thereby bringing jaws **81** and **82** together. A guide slot **89** is provided in cylinder **83** to allow movement of jaw **82** relative to cylinder **83**. To operate the clip, a surgeon manually squeezes the end caps **85** and **86** together against the force of spring **88**, thereby moving the cylinders together and simultaneously moving jaws **81** and **82** apart. The clip can then be positioned for engagement with a vessel and the pressure on the end caps released, bringing the jaws together again in a clamped position in engagement with the vessel.

[0057] Resilient pads **91** and **92** are comprised of 50 durometer silicone (GE 6050) and attached to jaws **81** and **82** by means of a ridge **95** running lengthwise along the undersides of the pads. These ridges are received into corresponding T-shaped channels **97** and **98** in jaws **81** and **82**, respectively, and are secured in place by an adhesive **96**, such as silicone RTV (GE 118). The adhesive bonds with the pad to form a T-shaped section that is engaged by T-shaped channels **97**, **98**. As in the first embodiment, protrusions in the general shape of wedges **90** extend from each pad. The wedges are arranged in rows along the length of each pad and each wedge is oriented transverse to the length of the pad. The wedges of the first row are staggered relative to the wedges of the second row, that is, the wedges of the first row and second row alternate, as shown in **FIG. 21**. The upright ends of the wedges of the first row are formed flush with one side of the pad, and the inclined surfaces of the wedges slope downward and terminate at the other side of the pad. The wedges of the second row are arranged in reciprocal fashion.

[0058] This embodiment of the invention operates in similar fashion to the first embodiment. When the two pads are brought together, the wedges of one pad interdigitate with the wedges of the other pad and the inclined surfaces of the wedges of one pad mate with the inclined surfaces of the corresponding wedges of the opposed pad. The sides and raised ends of the wedges resist relative movement of a clamped vessel engaged between the two pads along directions parallel and transverse to the length of the pad. Unlike the first embodiment, this embodiment does not provide for gaps between the wedges. This embodiment has the advantage of being able to grip vessels of very small diameter that could otherwise slip through the gap spaces of the first embodiment. A surgical clip utilizing the pads of this embodiment can also perform alternative functions, such as use as a surgical "tag" for tagging sutures during surgery to aid a surgeon in identifying and locating sutures during the course of an operation. The wedges formed flush with one another and without intervening gaps provide for improved for gripping of sutures in the same fashion as for small diameter vessels.

[0059] The wedges have a height to width to length ratio ranging from about 1:1:2.5 to about 1:1:4 with the length of the wedge being generally equal to the overall pad width. Preferably, the wedges have a width of approximately 0.030 to 0.080 inches, a height of approximately 0.024 to 0.080 inches, and a length equivalent to the pad width, that is, about 0.10 inches. In the preferred embodiment, the wedges are 0.040 inches high, 0.040 inches wide and 0.10 inches in length.

[0060] Although only certain embodiments have been illustrated and described, those having ordinary skill in the art will understand that the invention is not intended to be limited to the specifics of these embodiments, but rather is defined by the accompanying claims.

We claim:

1. Surgical clamp members for attachment to opposing surfaces of jaws of a surgical clamping device, the jaws being mounted for movement toward and away from one another, the members comprising:

means for attaching the members to the opposing surfaces of the jaws; and

opposable resilient pads, each pad having a surface with protrusions extending therefrom for engagement with a vessel or other tissue received between the jaws, wherein:

a) the protrusions of each pad are arranged in one or more rows lengthwise along the pad; and

b) the protrusions of one pad interdigitate with the protrusions of the opposed pad when the jaws are moved toward one another.

2. The clamp members of claim 1 wherein said pads are of single piece construction.

3. The clamp members of claim 1 wherein said protrusions have gripping edges.

4. The clamp members of claim 1 wherein each pad has first and second sides and one or more holes passing through the pad and opening to both first and second sides.

5. The clamp members of claim 4 wherein each of said holes is cylindrical and has an axis transverse to the pad length.

6. The clamp members of claim 1 wherein each said pad surface is planar and the protrusions extending therefrom comprise wedges having planar surfaces inclined relative to the pad surface.

7. The clamp members of claim 6 wherein:

a) each said pad has first and second sides;

b) the wedges extending from each pad are arranged in first and second rows;

c) the wedges of the first row are staggered relative to the wedges of the second row;

d) the wedges of the first row have ends flush with the first pad side and inclined surfaces that slope downward to the second pad side; and

e) the wedges of the second row have ends flush with the second pad side and inclined surfaces that slope downward to the first pad side.

8. The clamp members of claim 7 wherein each pad has one or more cylindrical holes passing through the pad and opening to both first and second sides, and wherein each cylindrical hole has an axis transverse to the pad length.

9. The clamp members of claim 7 wherein the wedges of the first row and the wedges of the second row have gaps therebetween.

10. The clamp members of claim 7 wherein each of said wedges has a height, a width, and a length, the ratio of the height to width to length ranging from about 1:1:2.5 to about 1:1:4.

11. The clamp members of claim 1 wherein each said pad surface is planar and the protrusions extending therefrom are cylindrical and extend from the pad at right angles to the pad surface.

12. The clamp members of claim 11 wherein said protrusions have hemispherical tips.

13. The clamp members of claim 11 wherein said cylindrical protrusions have conical tips.

14. The clamp members of claim 11 wherein:

a) said protrusions form first and second rows lengthwise along the pad; and

b) the protrusions of the second row are staggered relative to the protrusions of the first row.

15. The clamp members of claim 14 wherein;

a) each pad has first and second sides and one or more cylindrical holes passing through the pad and opening to both first and second sides; and

b) each cylindrical hole has an axis transverse to the pad length.

16. The clamp members of claim I wherein said pads have a resilience ranging from about 30 to about 60 durometer.

17. Surgical clamp members for attachment to opposing surfaces of jaws of a surgical clamping device, the jaws being mounted for movement toward and away from one another, the members comprising:

means for attaching the members to the opposing surfaces of the jaws; and

opposable resilient pads, each pad having first and second sides and a surface with protrusions having gripping edges extending therefrom for engagement with a vessel or other tissue received between the jaws, wherein:

a) the protrusions of each pad are arranged in one or more rows lengthwise along the pad;

b) the protrusions of one pad interdigitate with the protrusions of the opposed pad when the jaws are moved toward one another; and

c) each pad has one or more cylindrical holes passing through the pad and opening to both first and second sides of the pad, each cylindrical hole having an axis transverse to the pad length.

18. The clamp members of claim 17 wherein said pad surface is planar and said protrusions comprise wedges extending from the pad and having inclined planar surfaces relative to the pad surface.

19. The clamp members of claim 18 wherein:

a) said wedges are arranged in first and second rows;

b) the wedges of the first row are staggered relative to the wedges of the second row; and

c) the wedges of the first row have ends flush with the first pad side and inclined surfaces that slope downward to the second pad side and the wedges of the second row have ends flush with the second pad side and inclined surfaces that slope downward to the first side.

20. The clamp members of claim 17 wherein said protrusions are cylindrical.

21. The clamp members of claim 17 wherein said pads are of single piece construction.

22. The clamp members of claim 17 wherein said pads have a resilience ranging from about 30 to about 60 durometer.

23. Surgical clamp members for attachment to opposing surfaces of jaws of a surgical clamping device, the jaws being mounted for movement toward and away from one another, the members comprising:

means for attaching the members to the opposing surfaces of the jaws; and

opposable resilient pads, each pad having first and second sides and a surface having wedges extending therefrom for engagement with a vessel or other tissue received between the jaws, wherein:

a) the wedges of each pad are arranged in first and second rows;

b) the wedges of the first row are staggered relative to the wedges of the second row;

c) the wedges of one pad interdigitate with the wedges of the opposed pad when the jaws are moved toward one another, and

d) each pad has one or more cylindrical holes passing through the pad and opening to both first and second sides of the pad, each cylindrical hole having an axis transverse to the pad length.

24. The clamp members of claim 23 wherein said pads are of single piece construction.

25. The clamp members of claim 23 wherein said pads have a resilience ranging from about 30 to about 60 durometer.

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